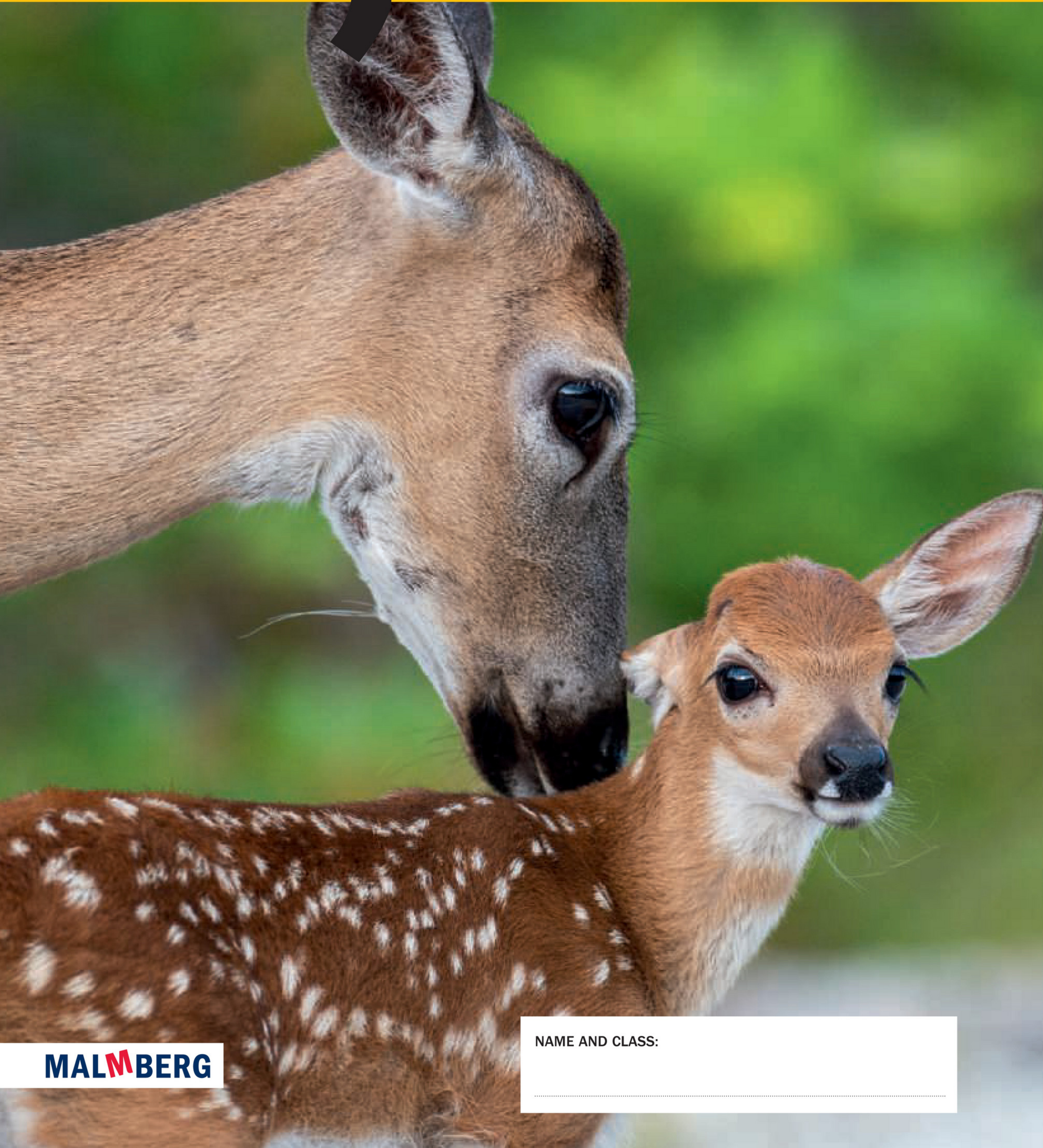


bvj

HAVO|VWO TTO

Biologie voor jou



bvj

1 HAVO|VWO deel B

Biologie voor jou TTO

BIOLOGIE VOOR TWEETALIG ONDERWIJS

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Getting started with *Biologie voor jou TTO*

Biology is all around you. *Biologie voor jou TTO* puts all the tools within easy reach that you need for experiencing, enjoying and discovering it! The introductory chapter first tells you what biology is about, why the subject is important and what you can do with it.

1 Organisms

LEARNING OBJECTIVES

1.1.1 You can explain what an organism is.
1.1.2 You can list the seven life processes.
1.1.3 You can distinguish between things that are living, dead or non-living (never alive).

► Learning how to do research 1
► Practical activity 1

TAXONOMY	1.1.1	1.1.2	1.1.3
Remembering	1a	2	
Understanding	1bc, 5	3, 5	4, 5
Using	10b	7a, 8, 10ac	6
Analysing		7bc, 9	7bc

The Greek word for life is *bios* and *logos* means a study or science. Together these two words make 'biology': the study of life.

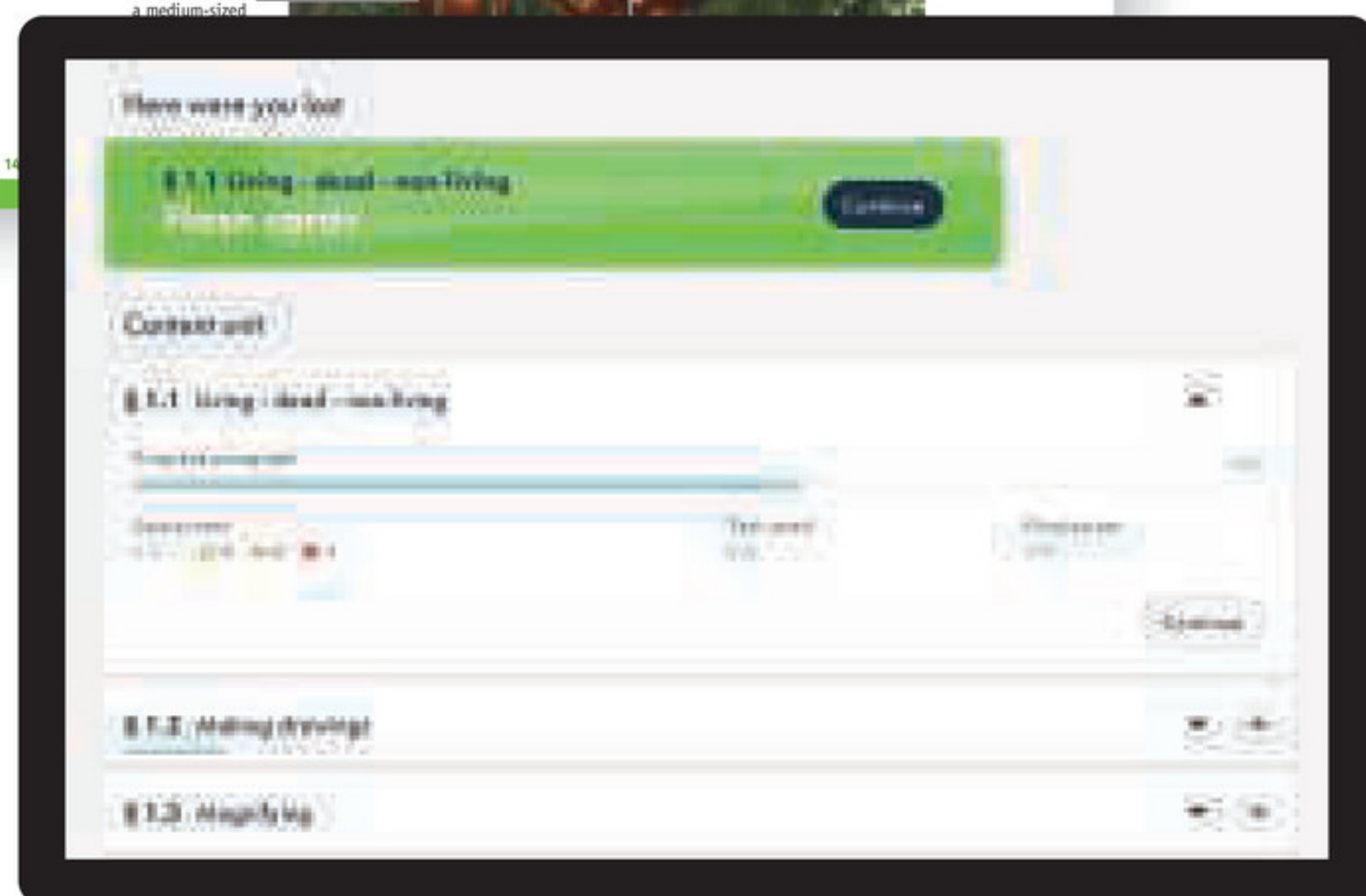
LIVING CREATURES

Biology is about organisms. An **organism** is a living creature. Humans, animals and plants are organisms, just like bacteria and fungi are. All organisms have **life processes**. The life processes tell you whether something is **living** and therefore an organism. A stone does not have life processes, so a stone is not an organism.

You can see the life processes of an orang-utan in figure 1. The seven life processes are:

- breathing
- feeding
- excreting
- sensing
- moving
- reproducing
- growing

fig. 1 Life processes in an orang-utan.



7 The importance of photosynthesis

LEARNING OBJECTIVE

1.7.16 You can explain that many fuels and raw materials exist thanks to photosynthesis.

TAXONOMY	LEARNING OBJECTIVE AND EXERCISES
Remembering	1.7.16
Understanding	1a
Using	1bcd, 2, 3
Analysing	

Plants can make glucose by photosynthesis. The plant can use glucose to make other substances. People depend on raw materials that were created thanks to photosynthesis.

FUELS

Natural gas, petroleum and coal are commonly used fuels. Petroleum is used to make petrol for cars. Many homes still have boilers that use natural gas. Coal is mainly used as fuel in power plants.

These fuels were formed from the remains of dead organisms that ended up on the sea bed millions of years ago. There they got compressed more and more by new layers of sand. The high pressure and heat changed the remains into coal, petroleum and natural gas. These are called **fossil fuels** (see figure 1). Fossil fuels originated from organisms that could live and grow thanks to photosynthesis.

fig. 1 Fossil fuels.



Work in your book *and* work online!

There are two books for each school year plus an online learning environment. Your teacher will decide what you do online (with a laptop, tablet or phone) and what you do in your book.

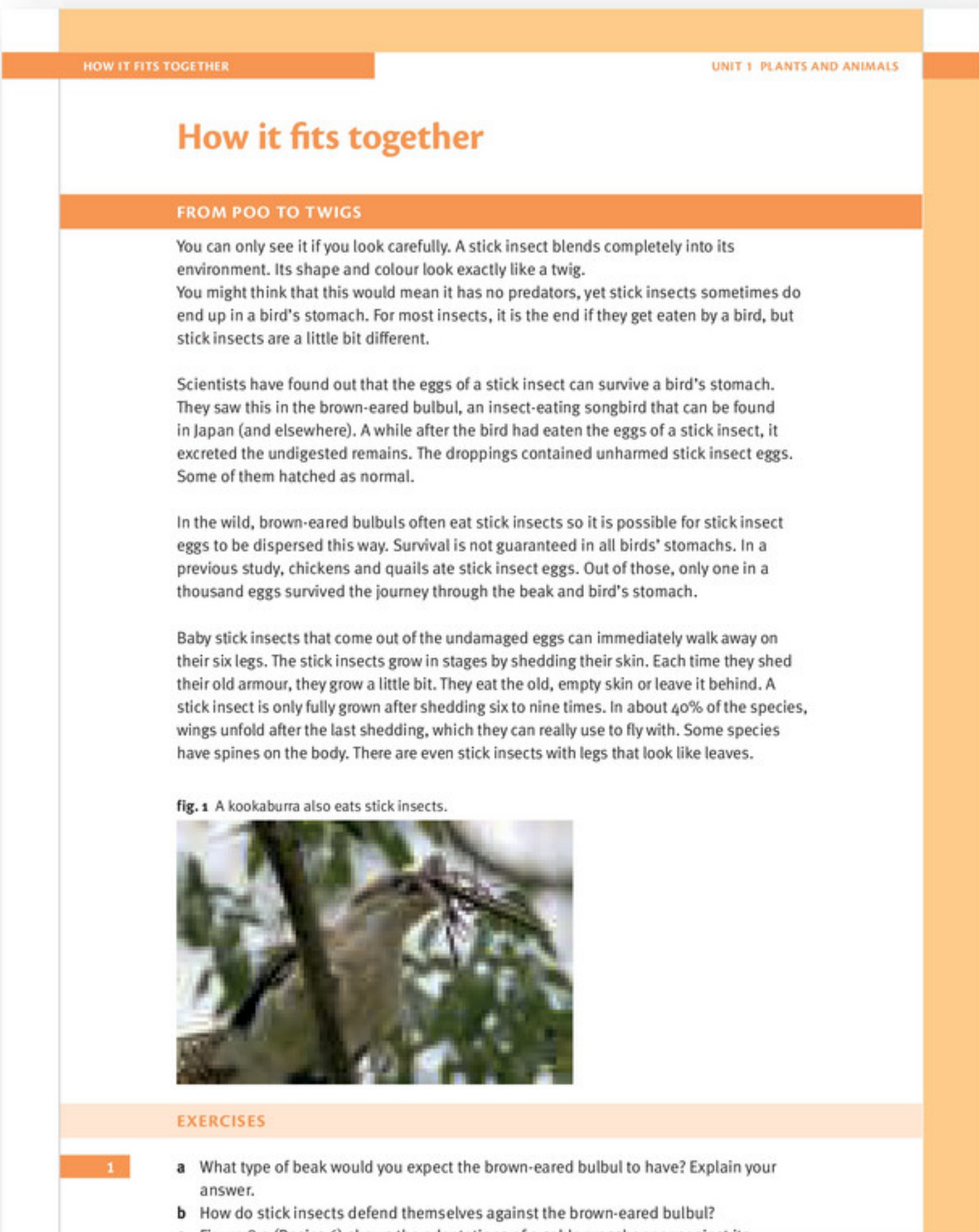
Each unit is split up into a Basics section, an Extra section, practical activities and a closing section. Learning objectives are always given at the start, telling you what you are going to learn and what level of taxonomy you will be using in the practical activities for the material you have learned. You can do the Extra sections if you want to know more or are feeling curious or have some spare time. In the activities section, you will do exercises and learn how to study and do research.

The advantages of working online

- You quickly see what you are doing correctly and what you are doing wrong.
- You get feedback on your answers straight away.
- You can watch video clips and animated clips.
- You learn the concepts and test yourself using the *Flash cards*.
- You can use the *Test yourself* sections, the practice test and the diagnostic test to see if you have understood the material.
- You can work at a higher or lower level or for a different school year.
- Your teacher will monitor how you are doing.

How it fits together

There is a section called *How it fits together* at the end of each Basics section and after all the Basics sections as a whole. These are in an orange frame. The way things fit together shows you why the course material is important in the world around you. You also learn to see connections between the information in the various Basics sections.

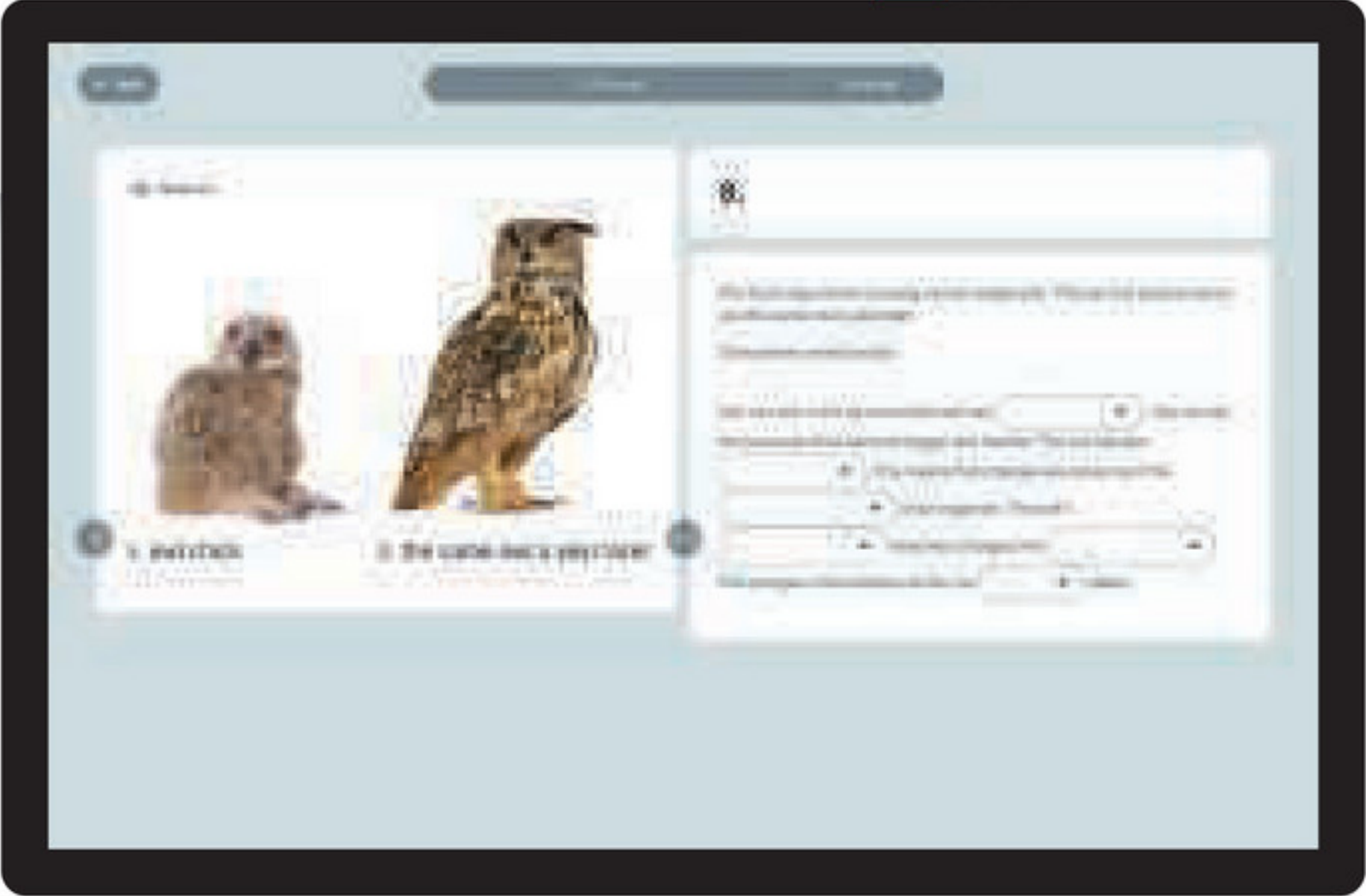
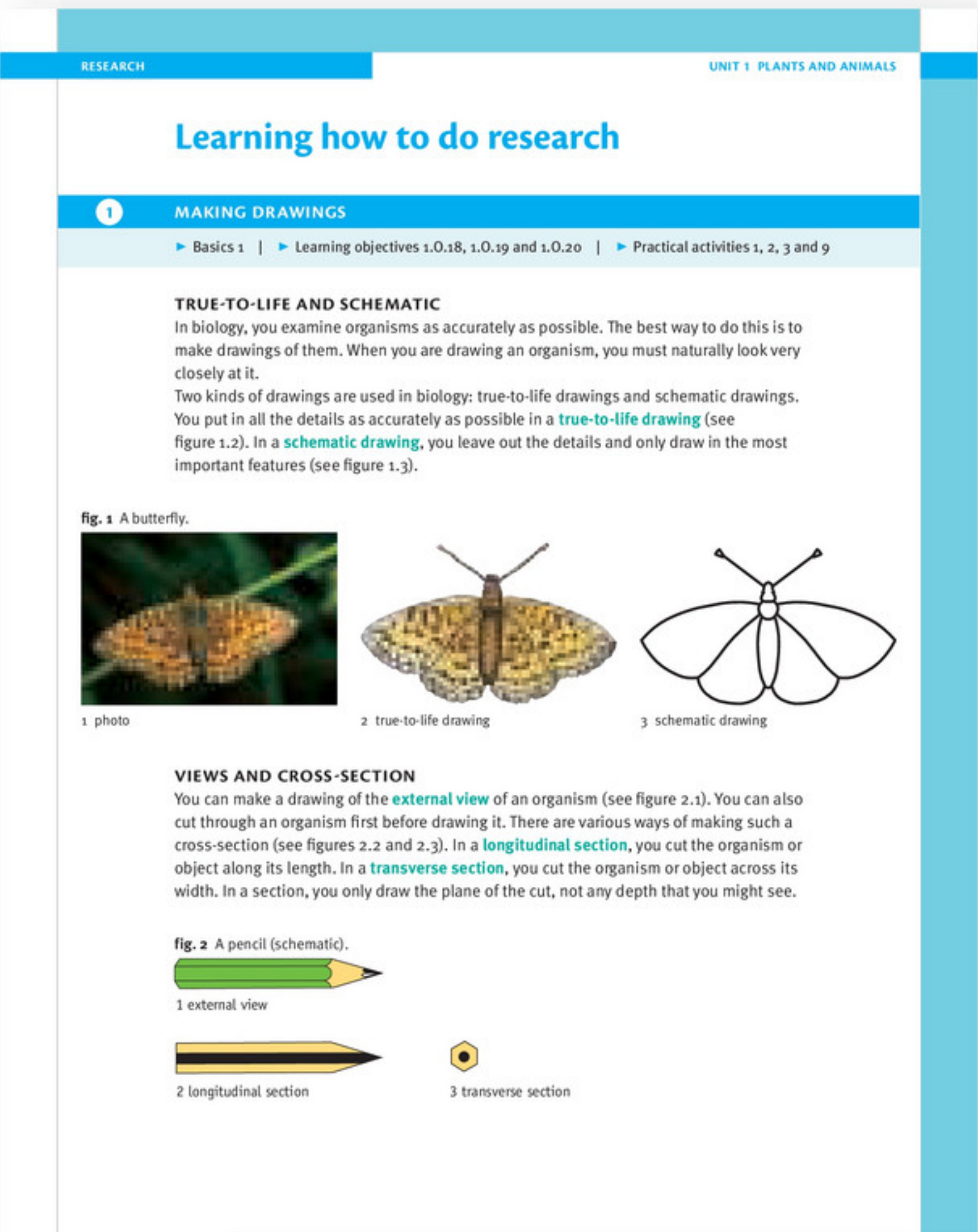


The advantages of the book

- You get a quick overview of what you will be learning.
- You can read the longer texts on paper.
- You can annotate the text and add remarks.
- You will be making drawings and adding colour yourself, which helps you remember things better.

Good preparation for the test!

The units end with a closing section (Summary). This is also where you can find the **Flash cards** for learning all the concepts. There is also a **Diagnostic test**. If you are not sure that you understand the material well enough, you can do the **Test yourself** section or the **Practice test**.



Meaning of the symbols

- This exercise is best done in your book.
- Go to the online learning environment for some useful extras.
- This is how long this practical activity will take.
- This exercise is extra challenging.

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INTRODUCTION

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- 2 Growth and development
- 3 Metamorphosis
- 4 Humans
- 5 Making food
- 6 All different
How it fits together
From poo to twigs

EXTRA

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- 8 Young that stay and young that go

RESEARCH

Learning how to do research
Practical activities

TO FINISH

Summary
Diagnostic test



Unit 2 Organs and cells

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- 2 The organs of plants
- 3 Tissues
- 4 Cells
- 5 The cell nucleus
- 6 Cell division
How it fits together
Baobab trees are dying

EXTRA

- 7 Single-celled organisms
- 8 DNA testing

RESEARCH

Learning how to do research
Practical activities

TO FINISH

Summary
Diagnostic test



Unit 3 Classification

BASICS

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- 2 Similarity and kinship
- 3 Animals
- 4 Plants
- 5 Fungi
- 6 Bacteria
How it fits together
Water bears under your beach towel

EXTRA

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- 8 Arthropods

RESEARCH

Learning how to do research
Practical activities

TO FINISH

Summary
Diagnostic test



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4

Support and locomotion

The skeleton in your body is sturdy and has muscles attached to it. The muscles and joints let you move. Exercise is good for your health.

BASICS

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1 The skeleton

LEARNING OBJECTIVES

- 4.1.1 You know the parts of the body.
- 4.1.2 You can name the bones in a picture of the skeleton.
- 4.1.3 You can name the functions of the skeleton.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	4.1.1	4.1.2	4.1.3
Remembering	1abd	2, 3	4
Understanding	1c, 5	5	5
Using	9abc	6ab, 7a, 9b	9d
Analysing	6c	6d, 7b	6cd, 7c, 8

Mammals have an internal skeleton with a spinal column. Humans are mammals too and so they also have an internal skeleton.

THE STRUCTURE OF THE SKELETON

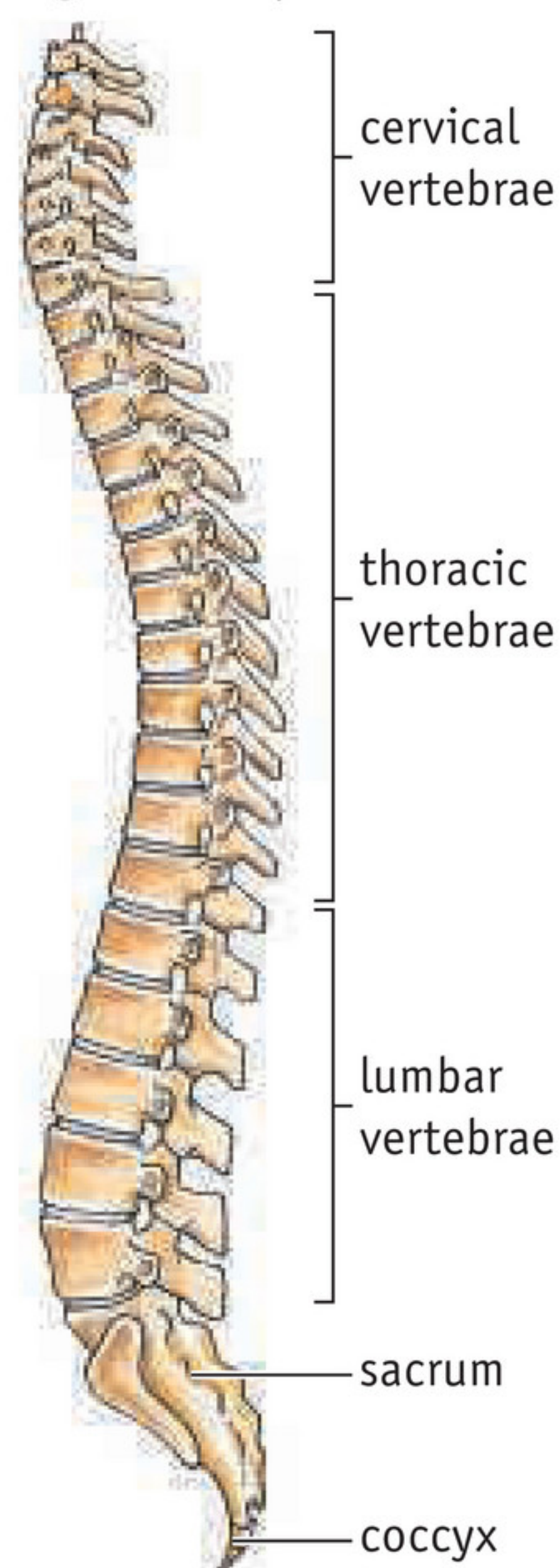
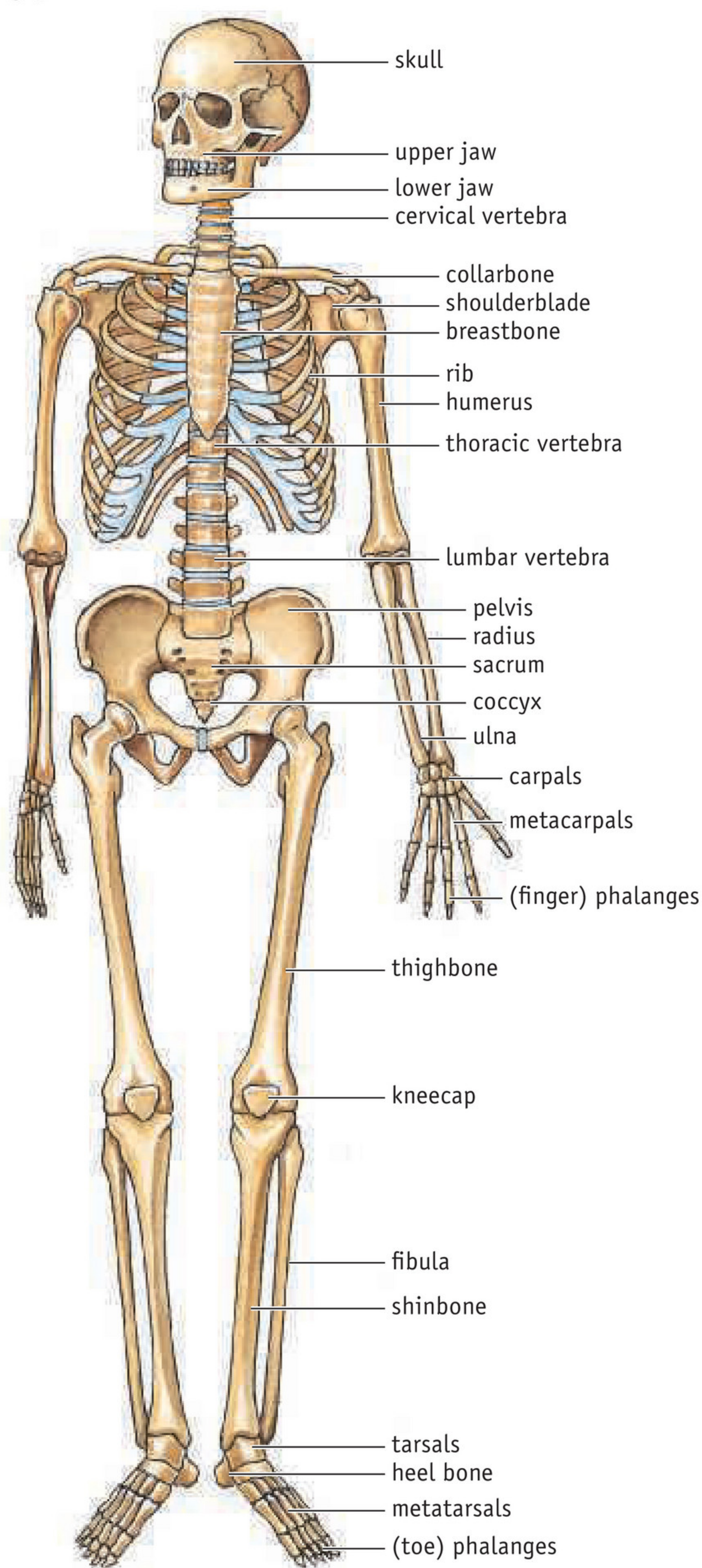
The human skeleton consists of roughly two hundred bones. Another name for all the bones together is the skeletal system. Figure 3 is a drawing of a human skeleton.

HEAD, TORSO AND LIMBS

You can divide the human body into a head, torso and limbs (arms and legs). The head bones create the skull. The skull includes the upper and lower jaw bones (see figure 1). The skull is supported by the spinal column (backbone), which consists of neck vertebrae (a vertebra is the name for a backbone segment), thoracic vertebrae and lumbar vertebrae (see figure 2). Underneath the lowest lumbar vertebra is the sacrum. The coccyx is located at the end of the sacrum. The thoracic vertebrae, the ribs and the breastbone together make up the ribcage. The shoulder blades and the collarbones are part of the pectoral girdle. The pelvis and the sacrum form the pelvic girdle.

fig. 1 The skull.



fig. 2 The spinal column.**fig. 3** The human skeleton.

The bones in your limbs have a similar structure. An arm consists of the humerus, the ulna, the radius and the hand bones. A leg consists of the thighbone, the tibia, the fibula and the bones of the foot. The ulna and the radius are difficult to tell apart. To help you remember: the **ulna**, the **shorter** word, is attached to the little finger, the **shortest** finger.

THE FUNCTIONS OF THE SKELETON

Because your bones are sturdy, you are able to stand upright. The skeleton gives your body sturdiness and rigidity. The skeleton also makes movement possible. Many bones are connected together in ways that let them move. The muscles attached to the bones make them move. The skeleton protects your organs. The ribcage protects the lungs and the heart, the skull protects the brain. The fourth function of the skeleton is to give your body its shape. The skull, for example, gives your head a rounded shape.

The shape of the skeleton and the bones is related to their function. The bones of the skull create a cavity together, which lets them protect the brain. Many bones have protrusions that muscles are attached to.

KNOWLEDGE

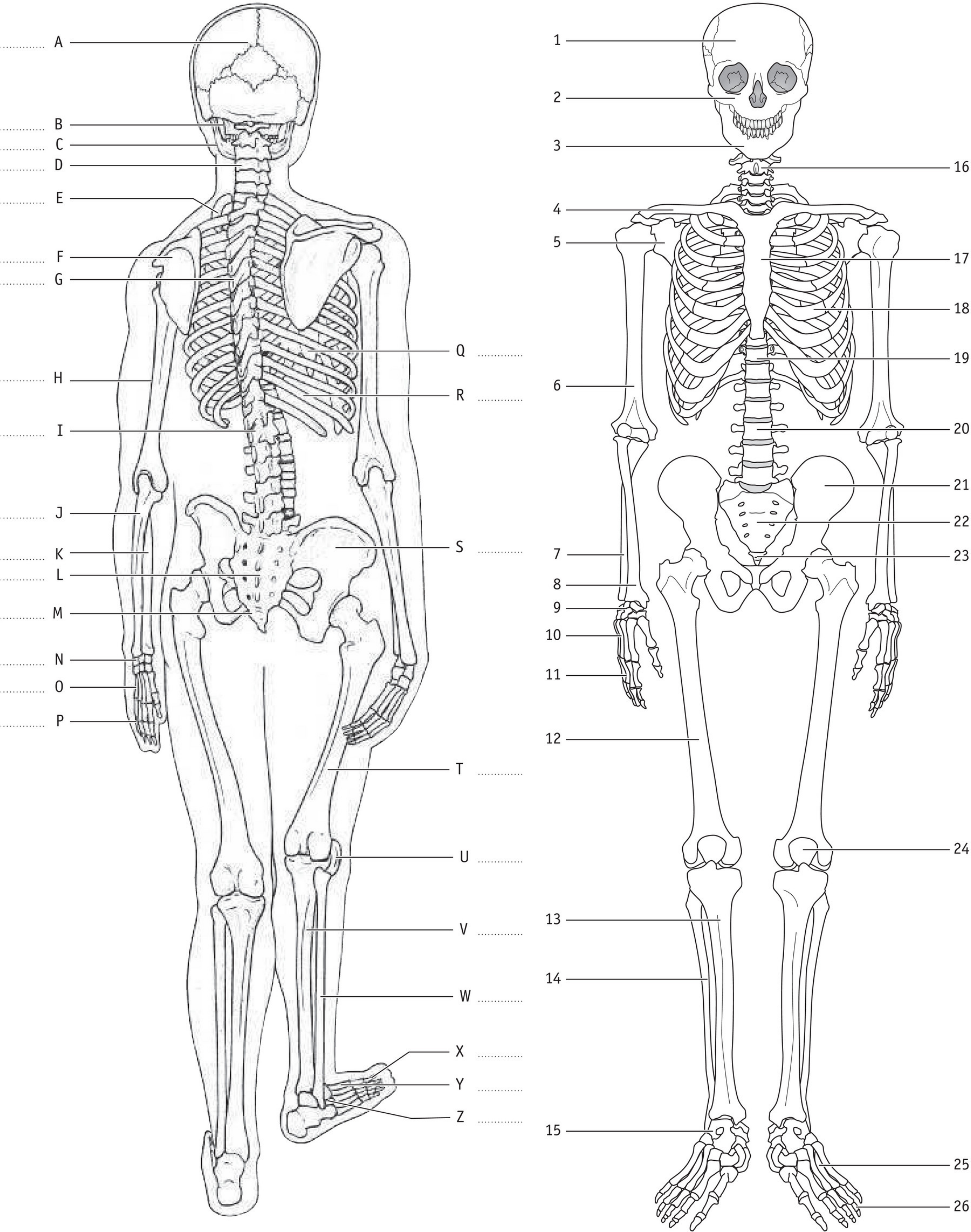
1

- a** The skeleton is also known as the
Your arms and legs are referred to as
- b** Which bones make up the pectoral girdle?
breastbone / thoracic vertebrae / neck vertebrae / sacrum / pelvis / lumbar vertebrae / ribs / shoulder blades / collarbones / coccyx
- c** Which vertebrae are the ribs connected to?
☐ A thoracic vertebrae
☐ B neck (cervical) vertebrae
☐ C lumbar vertebrae
- d** Which bones make up the pelvic girdle?
breastbone / thoracic vertebrae / neck vertebrae / sacrum / pelvis / lumbar vertebrae / ribs / shoulder blades / collarbones / coccyx

2

Figure 4 shows a human skeleton seen from the back and the front. The bones in the back view have letters and the front view has numbers.
For each letter, write down the number of the corresponding bone.

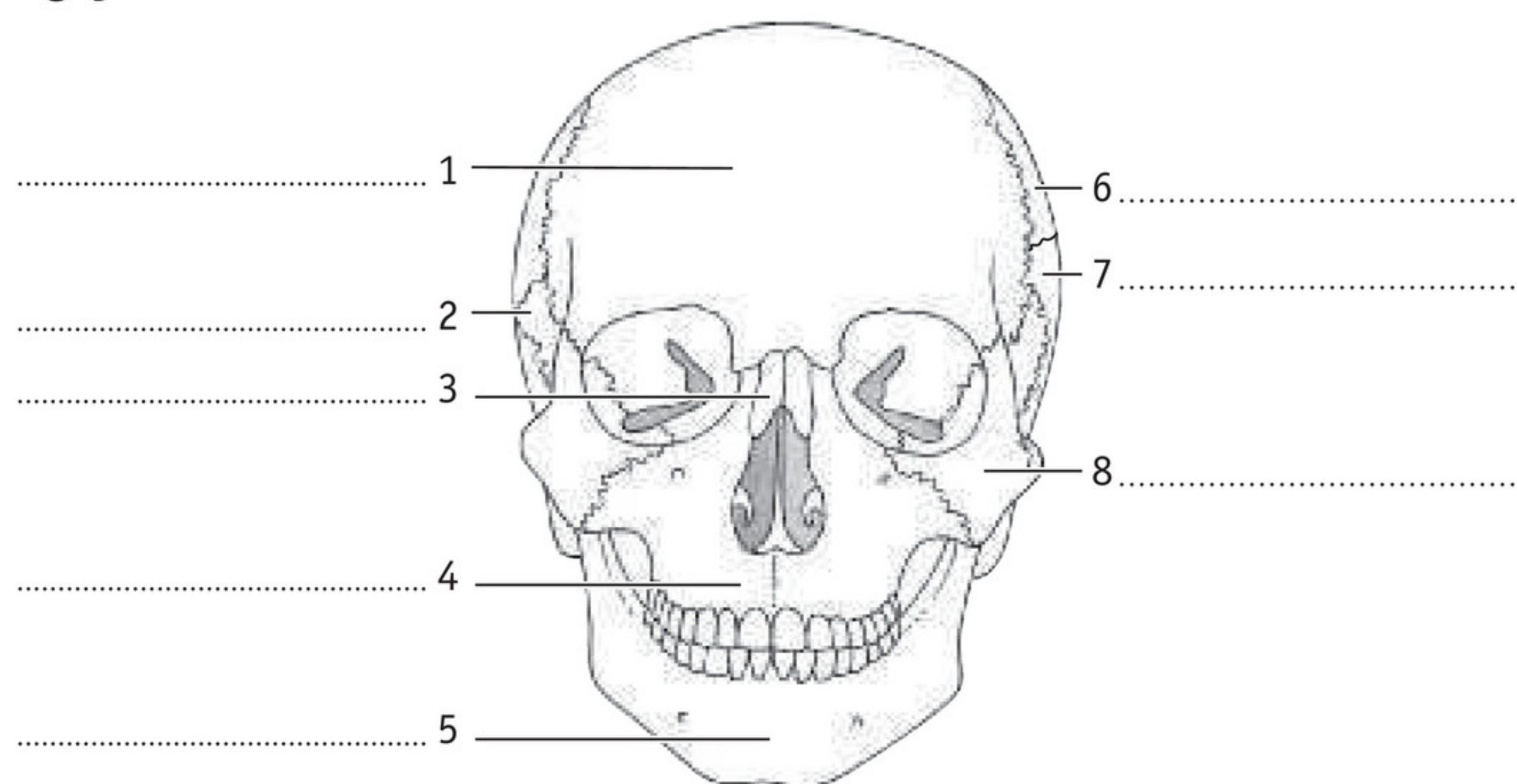
fig. 4 The human skeleton (back and front).



3

Figure 5 shows the bones in the head from the front.
Write down the names by the numbered bones.

fig. 5 The human skull.



4

The skeleton keeps your body upright.

- a** What three other functions does the skeleton have?
- b** Many bones have protrusions.
What is one function of these protrusions?
- c** Which of the skeleton's functions is related to muscles?
 - ☐ A providing protection
 - ☐ B making movement possible
 - ☐ C giving the body sturdiness
 - ☐ D Giving the body its shape

5



Summary

Make a summary of this basic course material. Write down the names next to the numbered bones in figure 6 and answer the questions.

- What three sections make up the body?
- What are limbs?
- What functions does the skeleton have?

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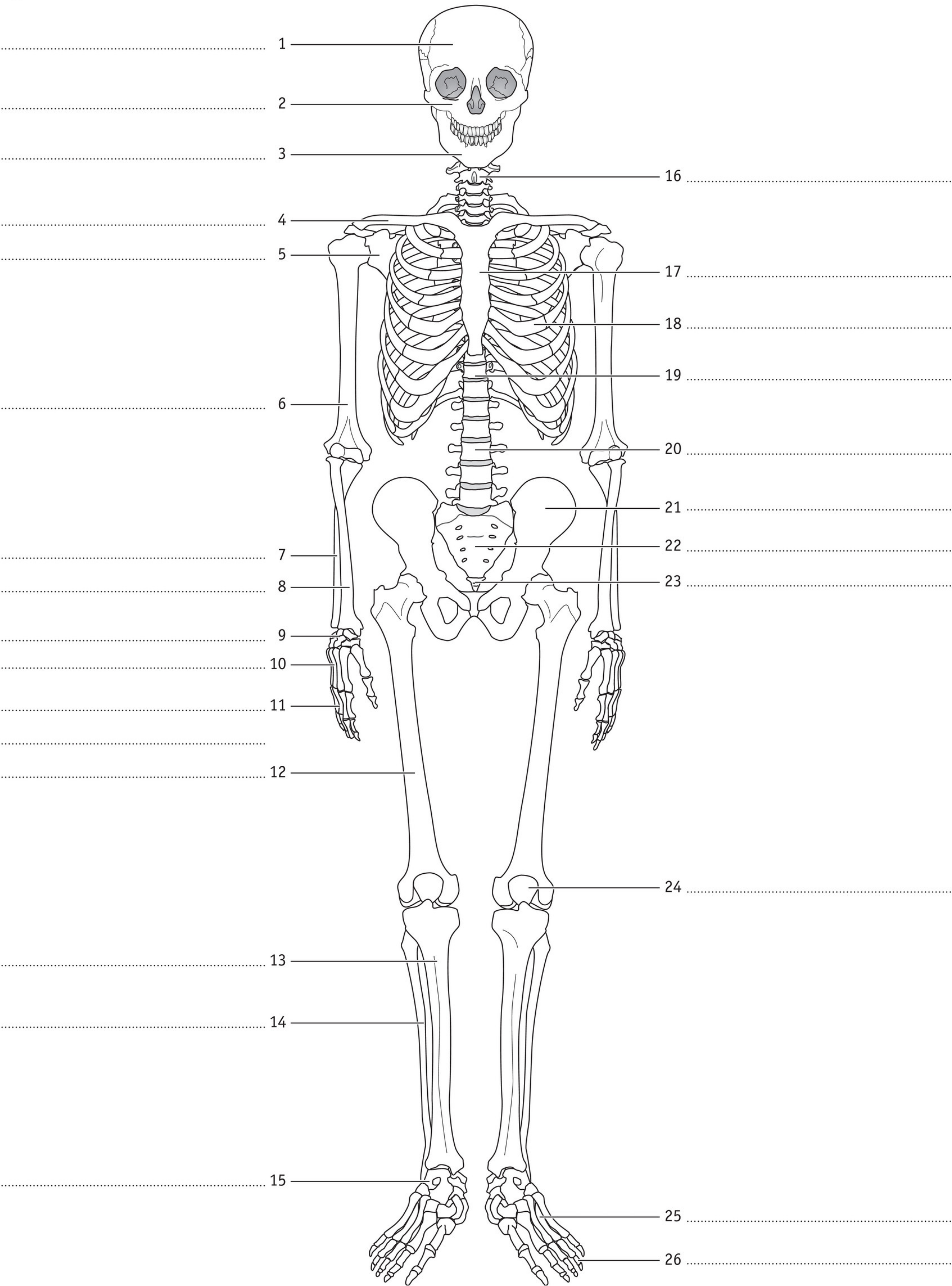
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fig. 6



INSIGHT

6

The bones in your limbs have a similar structure.

a Which bones in the arm and the leg are similar to one another?

- | | | |
|--------------------|-----------------------|---------------------------------------|
| A ulna | ☐ | ☐ 1 thighbone |
| B humerus | ☐ | ☐ 2 fibula |
| C radius | ☐ | ☐ 3 tibia |
| D finger phalanges | ☐ | ☐ 4 toe phalanges |

b Which bone in the leg does not have a corresponding bone in the arm?

c Which organs are protected by the shoulder blades?

d Which other bones protect these organs? Explain your answer.

7

Figure 7 shows the skeleton of a viper. The skeleton is similar to the skeleton of a human but humans have some bones that snakes don't have.

a Which bones doesn't a snake have?

- ☐ A occipital bone
- ☐ B lower jaw
- ☐ C rib
- ☐ D skull
- ☐ E tibia
- ☐ F collarbone
- ☐ G coccyx
- ☐ H vertebra

b There is another bone the viper doesn't have and this lets it swallow large prey in one go.

Which bone is that? Explain your answer.

c The human skeleton and the skeleton of a snake have the same functions.

Which function is a human skeleton better at?

- ☐ A providing protection
- ☐ B making movement possible
- ☐ C giving the body sturdiness
- ☐ D giving the body its shape

fig. 7 The skeleton of a viper.



+ 8

Figure 8 shows a barrage (a kind of dam). Barrages always have a curved shape. The water pushes against the curved wall with a huge force but the wall can withstand that force.

a Which three parts of your body have a similar curved shape?

b For which function of the skeleton is this curved shape useful? Explain your answer.

fig. 8 A barrage.

HOW IT FITS TOGETHER the living world

ACHONDROPLASIA

In the past, people with achondroplasia were sometimes laughed at and called dwarves. Fortunately that happens less nowadays, perhaps partly due to the success of *Game of Thrones* actor Peter Dinklage (see figure 9).

A baby with achondroplasia has arms and legs that are noticeably too short, small hands and feet, and a relatively large head. As the child grows, it develops bow legs and severe curvature of the back. The forearms are longer than the upper arms. The torso is normal in length. People with achondroplasia are just as intelligent as people without the condition. They can also live just as long as other people. Achondroplasia is as common in boys as it is in girls.

fig. 9 Peter Dinklage, a successful actor with achondroplasia.

9

Read the text about 'Achondroplasia'.

- a** Which bones are proportionately shorter in a child with achondroplasia?
thoracic vertebrae / thighbone / ulna / neck vertebrae / pelvis / fibula / lower jaw bone / humerus / tibia / shoulder blade / radius / toe phalanges / finger phalanges
- b** In a child with achondroplasia, the humerus is *shorter / longer* than the radius and the ulna.
- c** People with achondroplasia have proportionately larger heads.
 Are their heads larger than those of people who do not have achondroplasia? Explain your answer.
- d** Which function of the skeleton results in differences in the appearance of someone with achondroplasia compared to other people?

 Go to the *Flash cards* and the *Test yourself* section.

2 The structure of bones

LEARNING OBJECTIVES

4.2.4 You can describe the structure of bone tissue and cartilage tissue.

► Practical activities 1 and 2

4.2.5 You can describe how the composition of the bones changes during a person's life.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	4.2.4	4.2.5	4.1.3*
Remembering	1be, 2	3bc	
Understanding	1acd, 4, 8a	3ad, 4, 8a	
Using	5, 8b, 9ab	6a, 7, 8b, 9bd	
Analysing	8c	6bcd, 8cd, 9c	6d

*You can find this learning objective in another Basics section.

Your ears and nose contain flexible cartilage but most bones in your body are hard and rigid. They don't bend but they can break.

BONES AND CARTILAGE

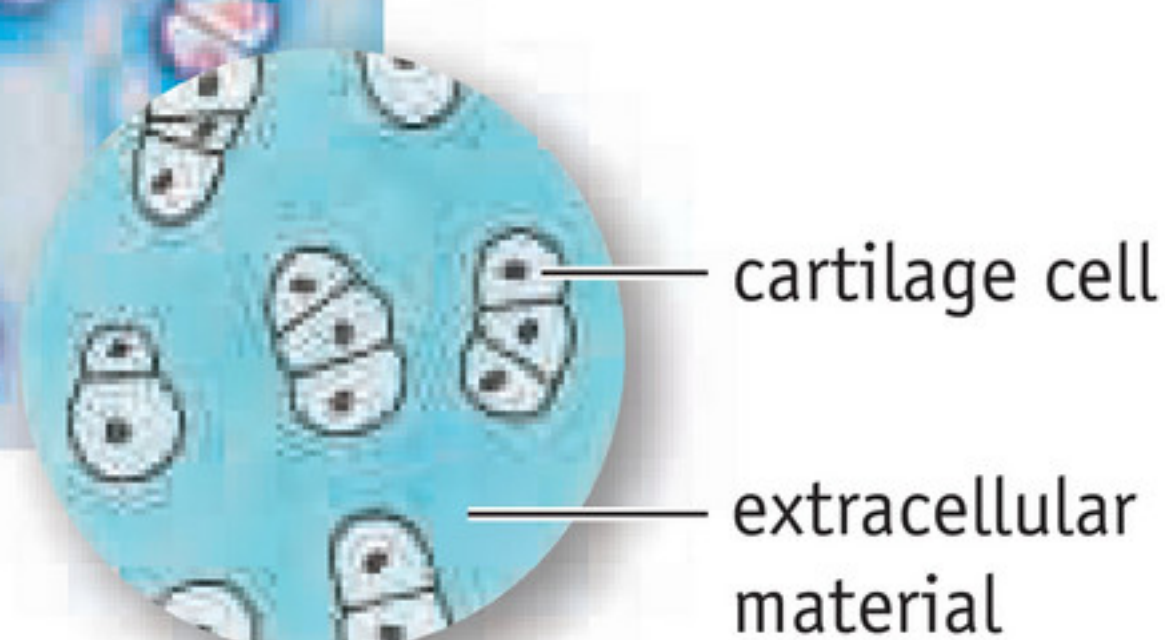
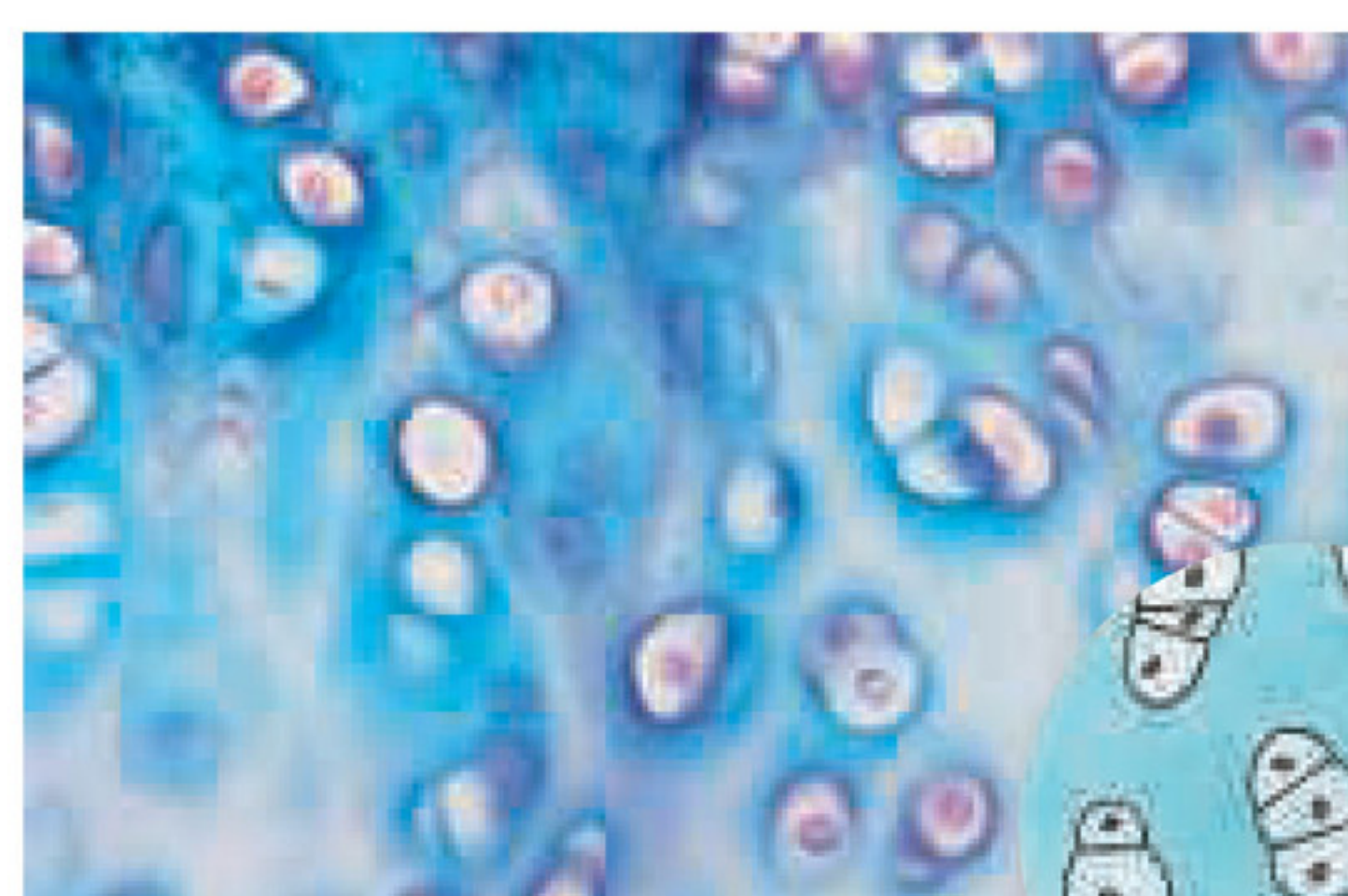
Bones consist mainly of calcium phosphate and collagen. A calcium salt called **calcium phosphate** makes the bone tissue strong and rigid. **Collagen** keeps the bone tissue a little bit flexible. Thanks to the calcium phosphate and collagen, bones are strong and do not bend or break easily.

Skeletons have two kinds of tissue: cartilage tissue and bone tissue. Both tissues have extracellular material between the cells.

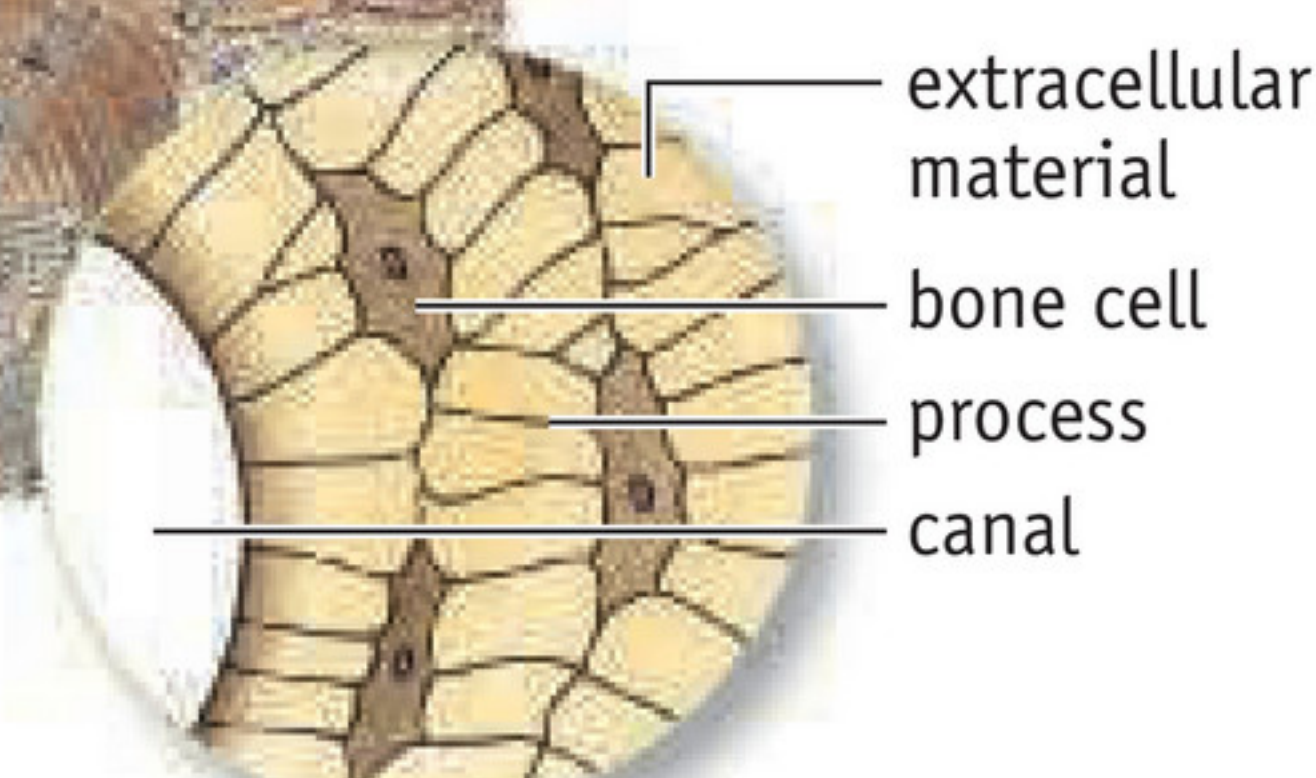
In **cartilage**, the cells are clustered together in elastic extracellular material (see figure 1.1). This extracellular material consists mainly of collagen. That is why cartilage is bendy. It is found in your nose, in your ears and between your ribs and breastbone. There is also cartilage between the vertebrae of the spinal column.

In **bone**, the cells are in rings surrounding tiny channels (see figure 1.2). Blood vessels run through those channels. The bone cells are connected to each other by protrusions. The extracellular material in bones mainly consists of calcium phosphate and collagen. That is why bone tissue is hard and rigid.

fig. 1 Types of tissue.



1 cartilage tissue



2 bone tissue

CHANGES IN BONE TISSUE

The skeleton of a baby consists mostly of cartilage tissue. This is why a baby can easily put its toes in its mouth (see figure 2). During growth, most of the cartilage changes to bone.

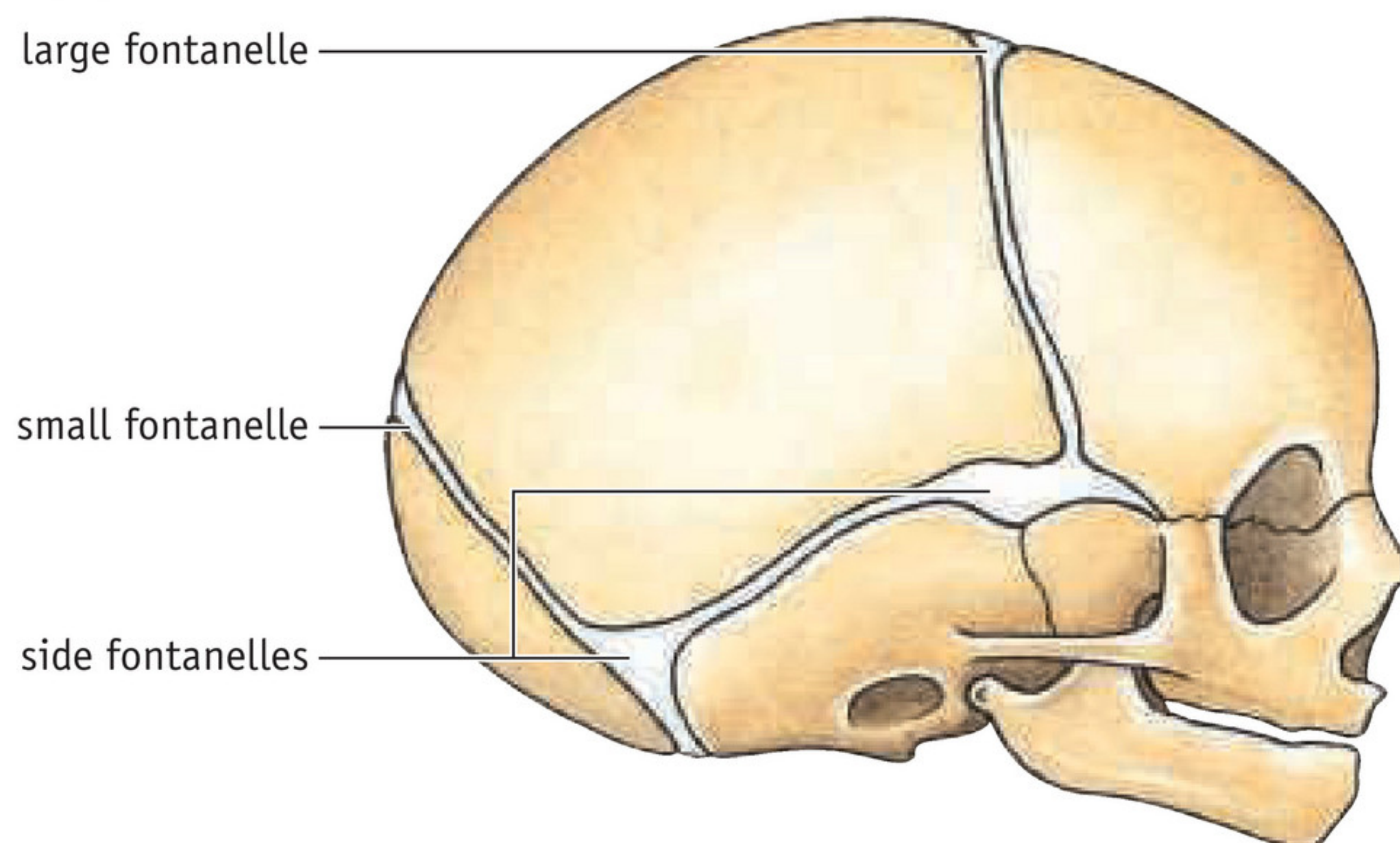
Children's bones still contain a lot of collagen. As they grow older, the amount of collagen in the bones decreases and the amount of calcium phosphate increases. The bones become less and less flexible as a result. In older people, the extracellular material doesn't contain much collagen at all. So their bones break more easily.

fig. 2 Flexible cartilage.



The bones of a baby's skull are not yet fused. There are gaps between the bones of a baby's skull that are filled with connective tissue (see figure 3). These gaps are called **fontanelles**. The fontanelles will have closed up after about 18 months and all you can then see are sutures between the bones.

fig. 3 Skull with fontanelles.



KNOWLEDGE

1

Bone tissue consists of bone cells and extracellular material.

- a** Extracellular material *is* / *is not* found in the bone cells.
- b** What does the extracellular material in bones consist of?
- c** What is the function of collagen?
- d** Bones contain both calcium phosphate and collagen.
Why is it important that bones contain both substances?
- e** The channels in bone tissue contain

2

- a** In which four places in the body will you find cartilage?
b How are the cells arranged in bone and in cartilage?

- A bone ☐ ☐ 1 in groups in the extracellular material
B cartilage ☐ ☐ 2 in rings around tiny channels

3

- a** Explain why the bones of children are more flexible than the bones of older people.
b As people grow older, the amount of calcium phosphate in their bones *decreases / increases*.
c What are fontanelles?
d Do children aged four to six also have fontanelles? Explain your answer.

4

**Summary**

Make a summary of this basic course material.

Difference between cartilage tissue and bone tissue:

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Functions of calcium phosphate and collagen:

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The composition of babies' bones:

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Composition of bone tissue as you grow older:

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Fontanelles:

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.....

Cartilage in adults:

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.....

INSIGHT

5

A bone has been left for some time in a solution of hydrochloric acid. This has dissolved the calcium phosphate from the bone.

a Is the bone more flexible or more breakable as a result? Explain your answer.

b A bone has been in a fire for some time and now it breaks easily.

Which substance has been removed from the bone? *collagen* / *calcium phosphate*

6

Babies have large heads in proportion to the size of their bodies. Before birth, the baby is located above the pelvis. During the birth, the baby passes through the narrow birth canal, the gap between the pelvis and the sacrum.

a Explain what the advantage of fontanelles is for the birth of a baby.

b At birth, the baby's skull is very big relative to the brain inside the skull. That difference rapidly becomes smaller during the first year.

Which grows faster in babies: the brain or the skull? Explain your answer.

c Fontanelles are important during the birth.

What is another important function of fontanelles?

d Figure 4 shows an orthopaedic helmet. This helmet is used if the baby's skull is asymmetrical. The helmet gives the skull a better shape as it grows.

What is the maximum length of time that a baby should wear the orthopaedic helmet? Explain your answer.

fig. 4 A baby with an orthopaedic helmet.



7

The percentages of calcium phosphate and collagen in bone tissue change over the course of your life.

a Which of the diagrams in figure 5 shows this best?

☐ A diagram 1

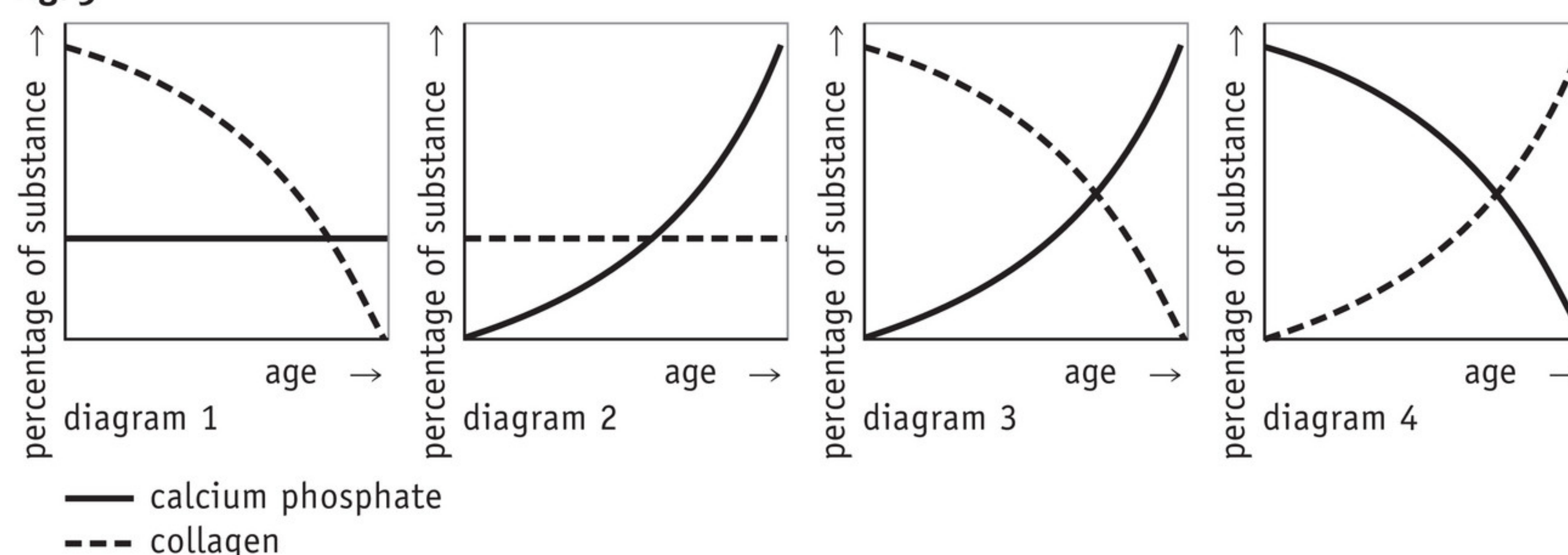
☐ B diagram 2

☐ C diagram 3

☐ D diagram 4

b Why does the hip bone break more easily in the elderly than in young people?

fig. 5



+ 8

In children, most bones have a disc-shaped piece of cartilage at the ends. These are the growth plates (or 'epiphyseal plates'). New cartilage is formed in the growth plate, which makes the bone longer at either end. After a while, the growth plates turn into bone. They become thinner and thinner, and eventually close up.

- a** Why can't an adult grow any taller?
- b** Figure 6 shows X-ray pictures of a hand and a wrist. X-ray pictures only show bone tissue, not cartilage.
Which picture shows the hand of a child? *picture 1 / picture 2*
- c** Write down two characteristics that let you see which hand belongs to a child and which hand belongs to an adult. You can also indicate them in the figure.
- d** A doctor can look at an X-ray of the hand and wrist and see how much the growth plates have already closed up. Based on that, they can determine the skeletal age or bone age of the person. That is the age that fits with how far the child's bones have developed.
Think of a method for how the doctor could estimate a child's skeletal age or bone age.

fig. 6 X-ray photographs of hands.



1



2

HOW IT FITS TOGETHER the living world

EXERCISING FOR STRONG BONES

Children and adolescents don't exercise enough. Instead of running and jumping around outdoors, they are indoors staring at a phone, tablet or television screen. Exercise just before and during puberty has a big influence on how strong the skeleton becomes eventually.

Bone cells can sense small movements in the fluid that surrounds them. If that fluid flows, new bone is formed. The more you move and the more forcefully you do so, the stronger your bones become. If you don't move, the fluid stands still and bone actually gets broken down. This can cause osteoporosis, where the bone becomes more porous. Osteoporosis is a disease of the elderly but it is increasingly happening in young people. So keep on exercising – for strong bones!

fig. 7 Children exercising at school.



9

Read the text 'Exercise for strong bones'.

Jogging and jumping are better for forming bone than gentle walking or swimming.

- a** Write down at least four bones that become stronger from jogging and jumping.
- b** As well as exercising, food with enough calcium phosphate, such as dairy products, is important for building strong bones.
Explain why.
- c** If bones are not put under much stress, they become less strong. Astronauts sometimes spend a long time outside the Earth's atmosphere in a spaceship with very little room. There is no gravity in the spaceship.
After a while in space, the bones of the astronauts become weaker. Write down two reasons for this.
- d** Experts say that children (aged 4 to 17) need at least one hour a day of moderate exercise, for example walking, cycling or doing household chores.
Make a note of how much exercise you do in a day and how intense that exercise is.
Compare your answers with at least two classmates.
What do you think: do you exercise enough or could you do more?

 Go to the *Flash cards* and the *Test yourself* section.

3 Joints

LEARNING OBJECTIVES

4.3.6 You can describe the types of joints.

4.3.7 You can describe the structure of a joint.

4.3.8 You can describe how a ball-and-socket joint, a hinge joint and a pivot joint work.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES			
	4.3.6	4.3.7	4.3.8	4.1.2*
Remembering	1abc	2ad		
Understanding	1de, 4, 5a	2bc, 4, 9abc, 10a	3, 4, 9abc, 10a	
Using	5bc	6b, 9d, 10bc	6c, 8abd, 9d	6a, 7a
Analysing		10d	7b, 8c	

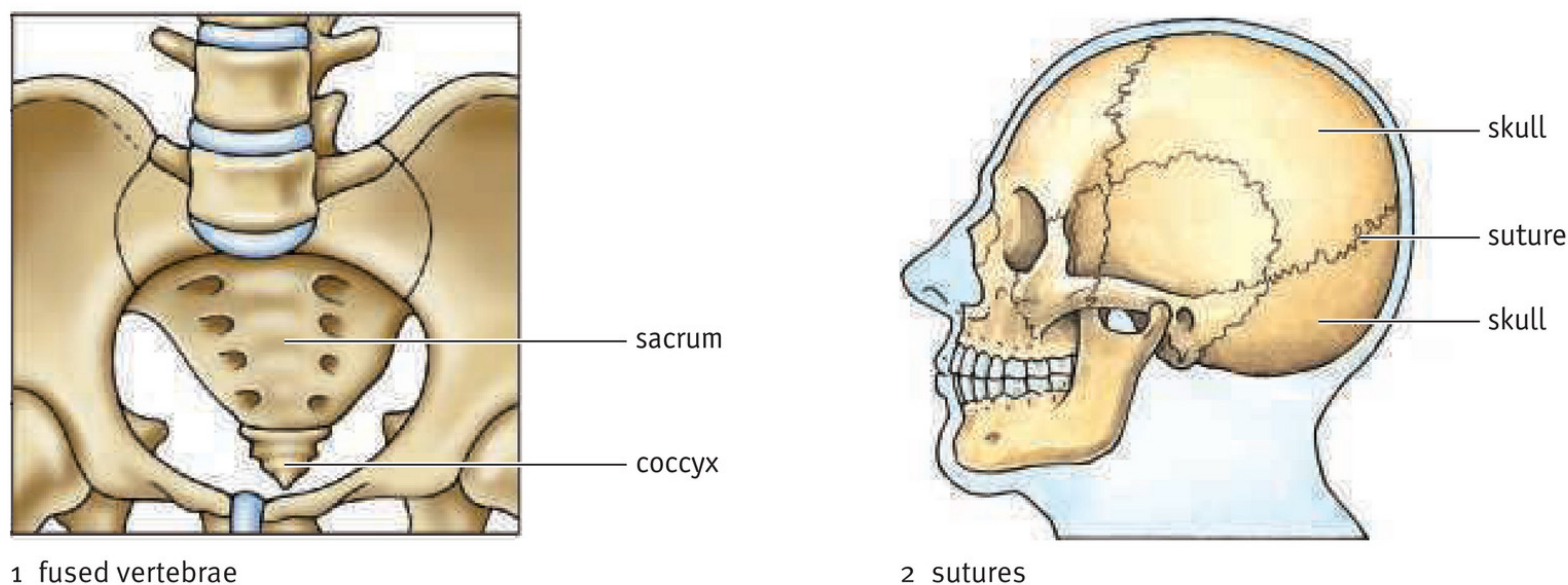
*You can find this learning objective in another Basics section.

Bones can be connected together in four ways: fused, with a suture, by cartilage or at a joint. Some connections are moveable but others are not.

IMMOBILE CONNECTIONS

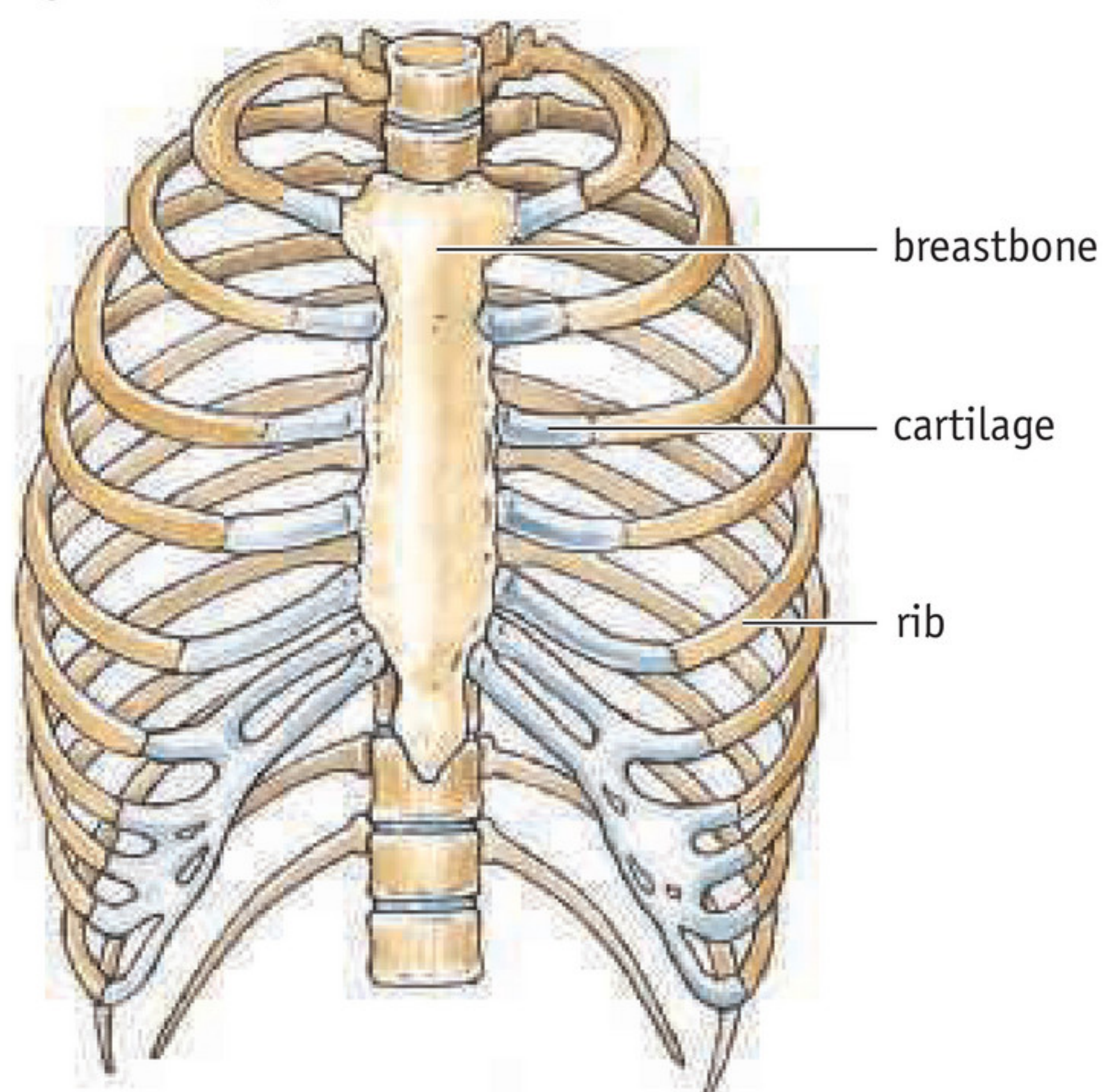
The sacrum consists of vertebrae that have **fused** together (see figure 1.1). The coccyx also consists of vertebrae that are fused together. The skull bones are connected by **sutures** (see figure 1.2). No movement is possible between fused bones or between bones attached by a suture.

fig. 1 Immobile connections.

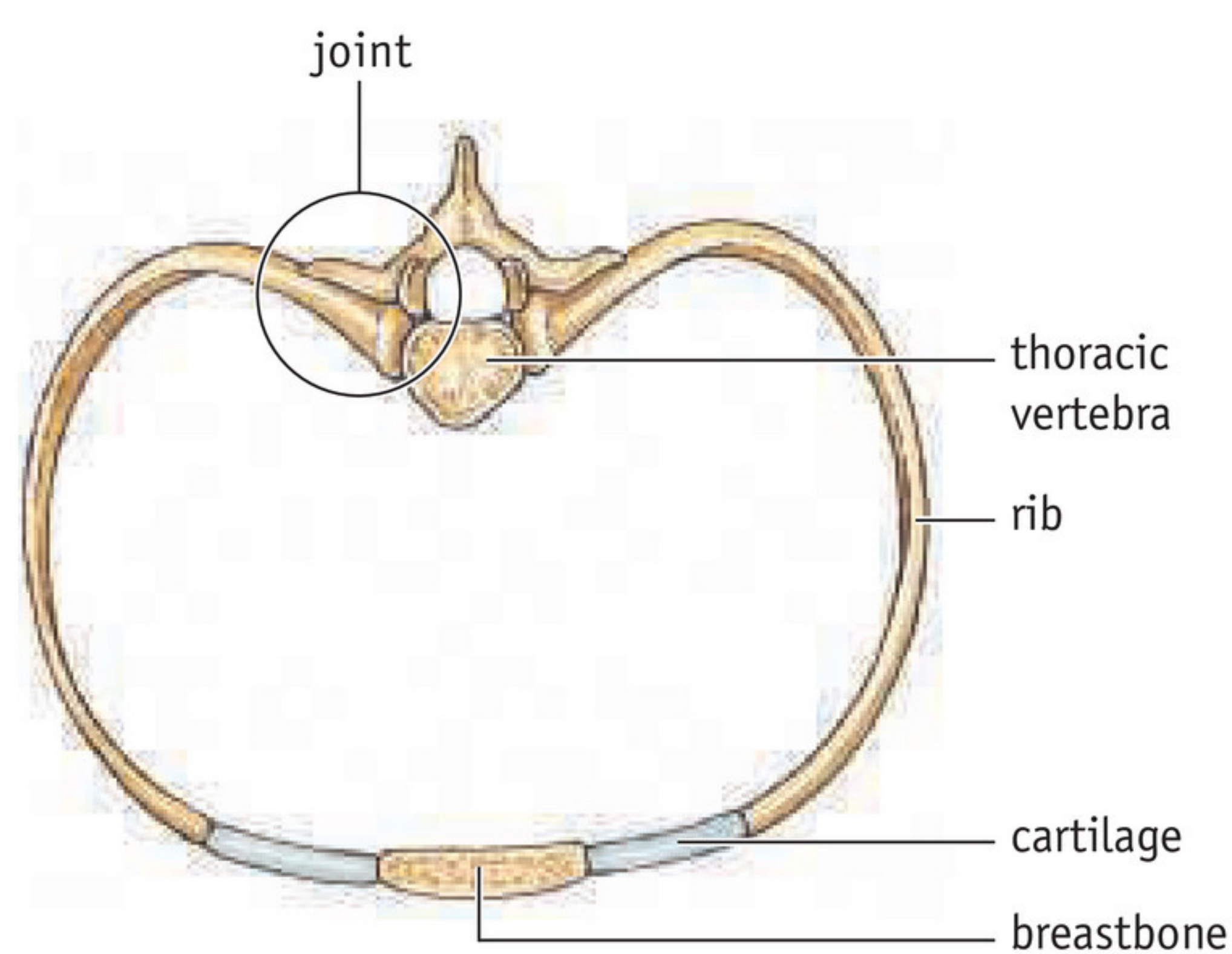


MOVING CONNECTIONS

Some bones are connected by cartilage, for example the ribs and the breastbone (see figure 2.1). The ribs and vertebrae are connected by joints (see figure 2.2). The cartilage and the joints allow the ribcage to expand and contract as you breathe.

fig. 2 Moving connections.

1 cartilage between the ribs and the breastbone



2 joints between the ribs and the vertebrae

THE STRUCTURE OF A JOINT

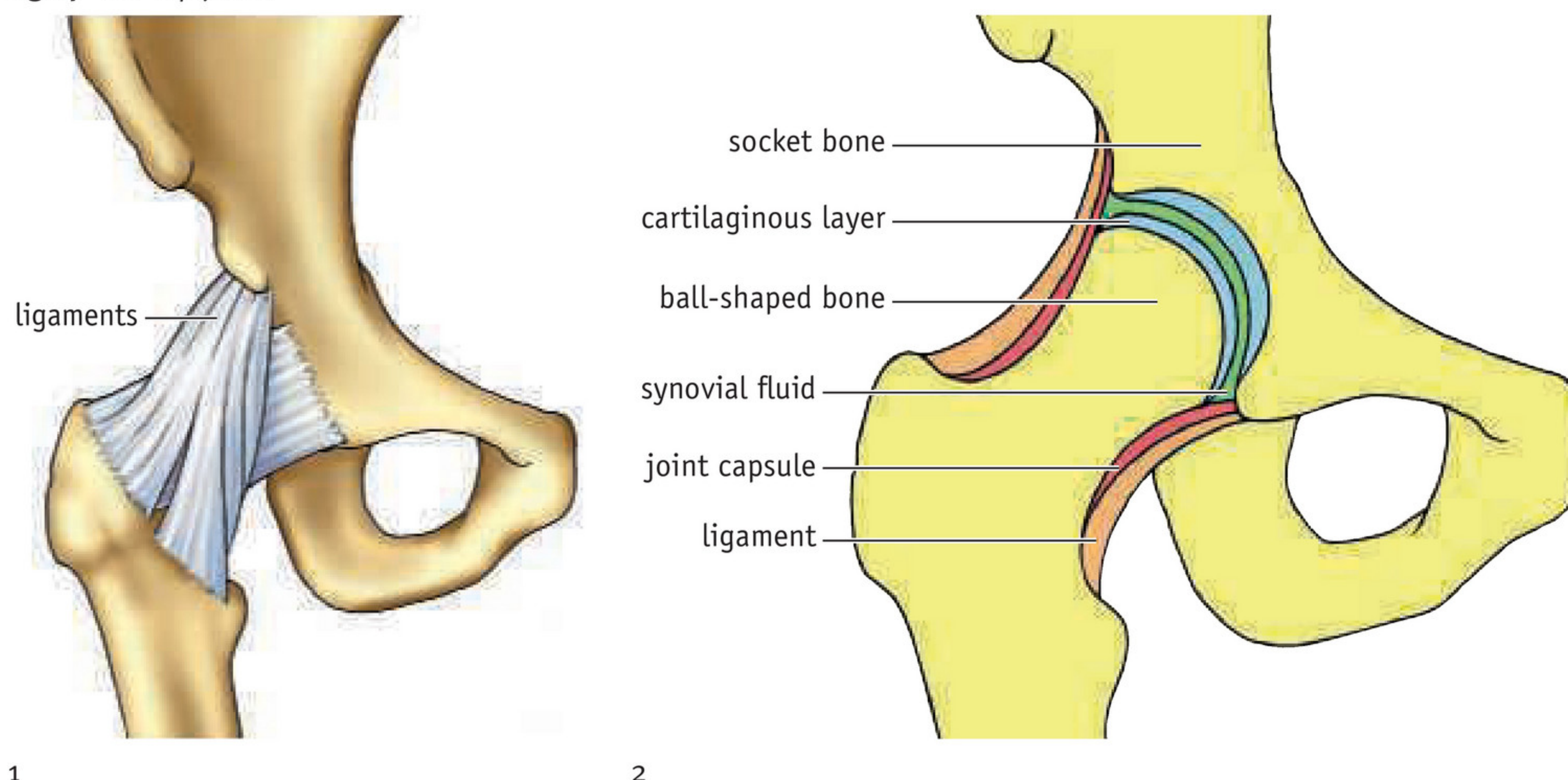
A **joint** is a connection between two bones. On one side there is a **convex bone** and on the other there is a **concave bone**. The convex bone can move in the hollow of the concave bone. The rounded end and the hollow end have a layer of cartilage (see figure 3). The cartilage lets the bones move smoothly and stops wear and tear.

fig. 3 Chicken bone with a layer of cartilage on the concave bone.

The two bones of a joint are held together by the **joint capsule**. The joint capsule keeps the bones in place. Some joints, such as the hip joint, also have strong **ligaments** around the joint (see figure 4). The ligaments also help keep the bones in place.

Synovial fluid is secreted on the inside of the joint capsule. This is a viscous liquid that acts as a kind of lubricant grease. It lets the bones move smoothly.

fig. 4 The hip joint.



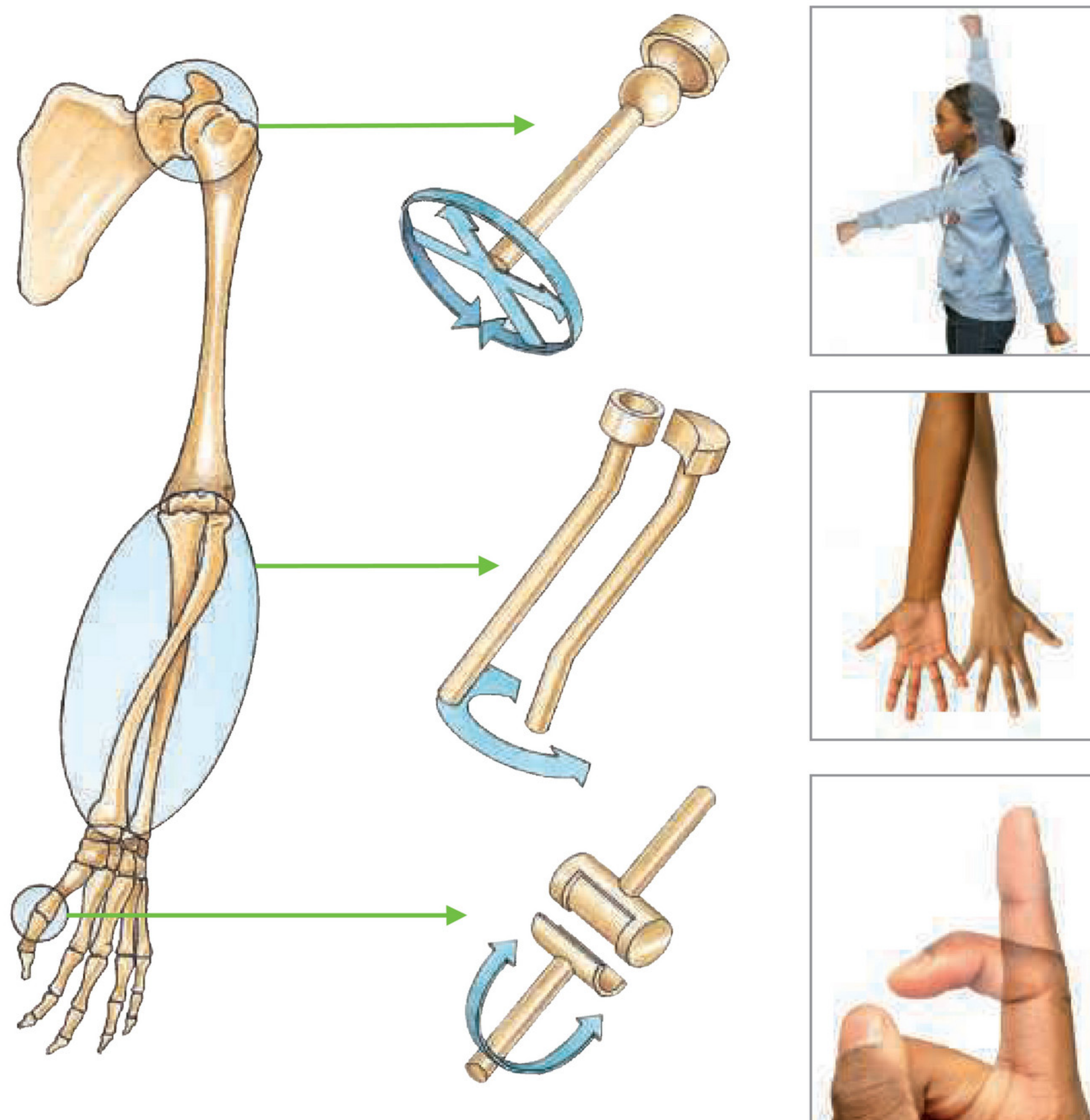
THREE TYPES OF JOINTS

The structure of a joint defines how the bones move with respect to each other. Three types of joint are the ball-and-socket joint, the pivot joint and the hinge joint (see figure 5).

There is a ball-and-socket joint in the shoulder. In a **ball-and-socket joint**, the ball-shaped end of one bone rotates in the socket of the other. That makes movement possible in various directions.

There is a pivot joint in your elbow. In a **pivot joint**, one bone rotates along its lengthwise axis around the other bone. This lets you turn your hand.

There are **hinge joints** between your finger phalanges. In this joint, one bone moves like a hinge with respect to the other. You can only move it back and forth.

fig. 5 Three types of joints.**KNOWLEDGE****1**

Bones are connected in various ways.

a Which connections allow movement?

- ☐ A fused
- ☐ B suture
- ☐ C cartilage
- ☐ D joint

b How are these bones connected together?

- 1 breastbone and ribs
- 2 pelvis and femur
- 3 lumbar vertebrae
- 4 humerus and ulna
- 5 parietal bone and frontal bone
- 6 sacral vertebrae
- 7 vertebrae in the coccyx

fused / suture / cartilage / joint
fused / suture / cartilage / joint
fused / suture / cartilage / joint
fused / suture / cartilage / joint
fused / suture / cartilage / joint
fused / suture / cartilage / joint
fused / suture / cartilage / joint

c How much movement does the connection allow?

- 1 fused
- 2 suture
- 3 cartilage
- 4 joint

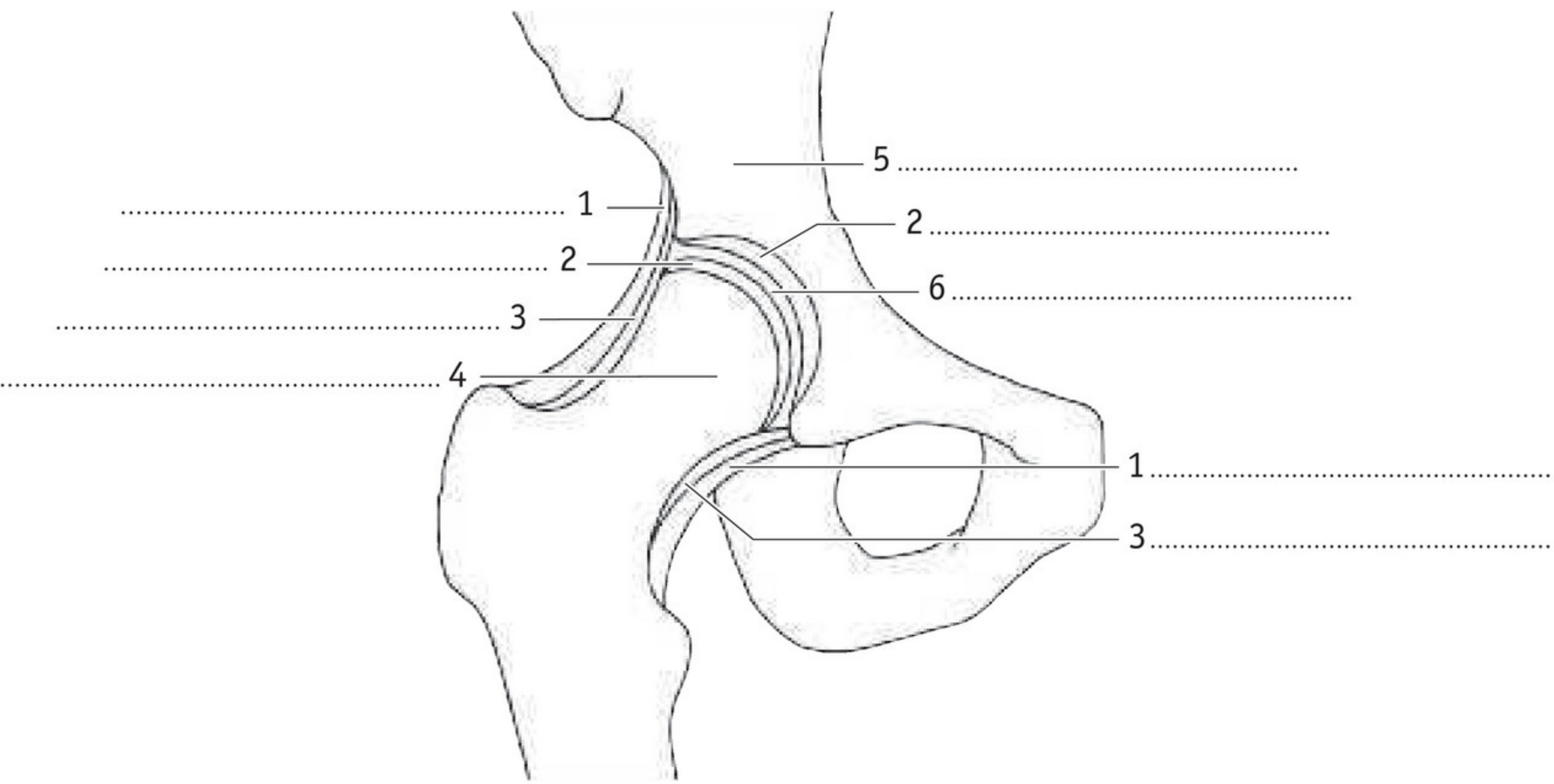
no / a little / a lot of movement is possible
no / a little / a lot of movement is possible
no / a little / a lot of movement is possible
no / a little / a lot of movement is possible

- d** Figure 2 shows drawings of a human ribcage.
Which types of bone connections are there in a ribcage?
- ☐ A fused
 - ☐ B suture
 - ☐ C cartilage
 - ☐ D joint
- e** Write down some bones that have immobile connections between one another.

2

- Figure 6 shows a schematic drawing of a hip joint.
- a** Write down the names of the numbered parts.
- b** Which two parts allow a joint to move smoothly?
1 / 2 / 3 / 4 / 5 / 6
- c** Which two parts keep the bones in a joint in place?
1 / 2 / 3 / 4 / 5 / 6
- d** Synovial fluid is made by the

fig. 6 A hip joint.



3

- For each joint, choose the correct type.
- | | |
|--|--|
| 1 femur and tibia | <i>ball-and-socket joint / pivot joint / hinge joint</i> |
| 2 first and second phalanges | <i>ball-and-socket joint / pivot joint / hinge joint</i> |
| 3 ulna and radius | <i>ball-and-socket joint / pivot joint / hinge joint</i> |
| 4 pelvis and femur | <i>ball-and-socket joint / pivot joint / hinge joint</i> |
| 5 humerus and ulna | <i>ball-and-socket joint / pivot joint / hinge joint</i> |
| 6 shoulder blade, collarbone and humerus | <i>ball-and-socket joint / pivot joint / hinge joint</i> |

4



Summary

Make a summary of the basics.

- Complete the tables.
- Make a schematic drawing of a joint and label the parts.

Four joints	Amount of movement

Part of the joint	Function(s)
Joint capsule	
Synovial fluid	
Ligaments	
Layers of cartilage	

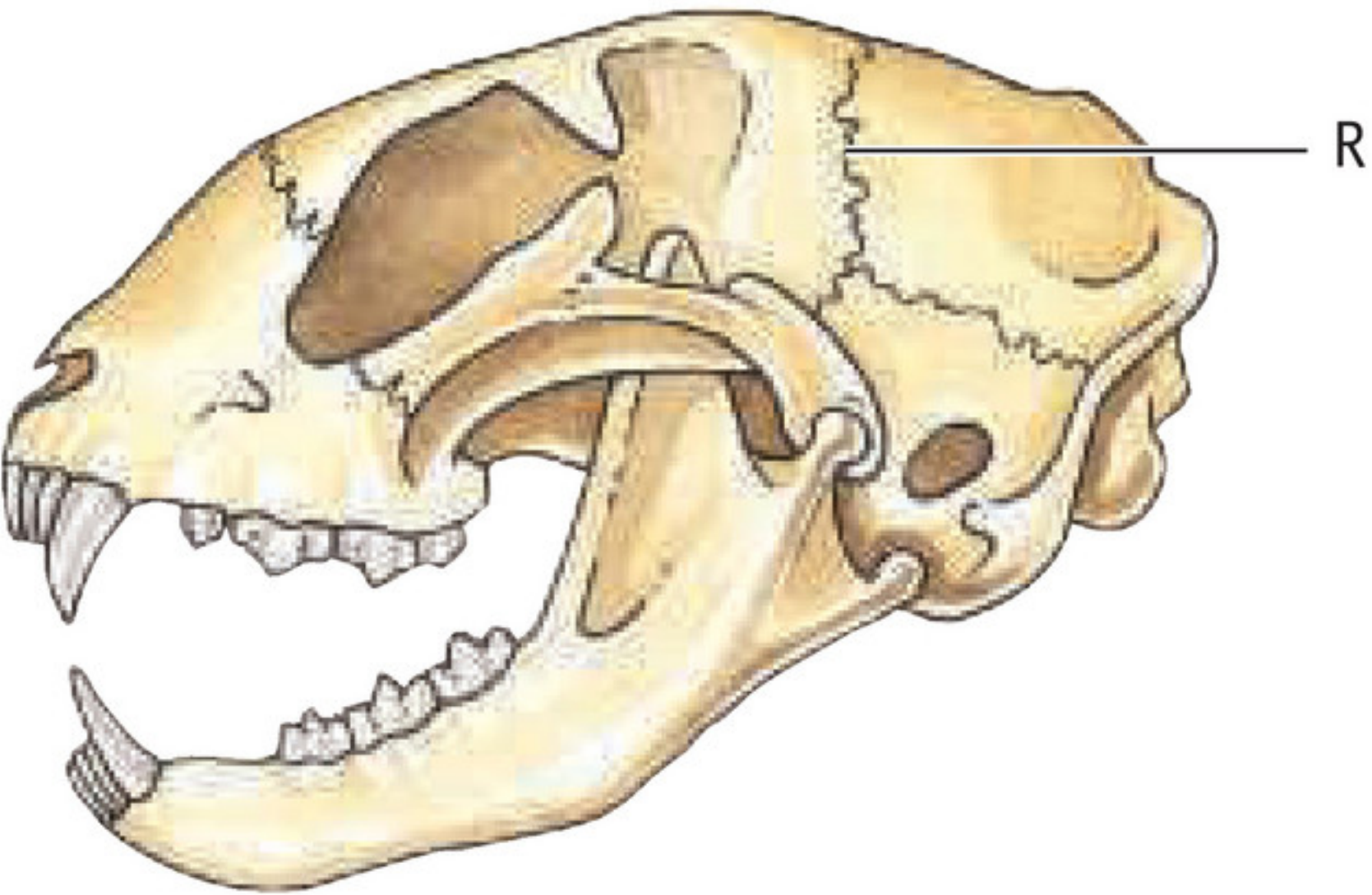
Three types of joints	Examples	How it works

INSIGHT

5

- Figure 7 shows the skull of a cat.
- a** What type of bone connection is R?
- ☐ A fused
 - ☐ B suture
 - ☐ C cartilage
 - ☐ D joint
- b** What other type of bone connection can you see?
- ☐ A fused
 - ☐ B suture
 - ☐ C cartilage
 - ☐ D joint
- c** Does this skeleton also have cartilage? Explain your answer.

fig. 7 Skull of a cat.



6

In X-ray photographs, the parts of a body appear whiter when they contain more calcium phosphate. That means you can see a broken bone clearly in an X-ray.

Figure 8 shows an X-ray of a hip.

- a The broken bone is called the
- b Why are many parts of a joint not visible on an X-ray?
- c The broken bone is connected to other bones by joints.
What types of joints connect up this bone? Explain your answer.

fig. 8 X-ray of a hip.



fig. 9 X-ray of a hand and wrist.



7

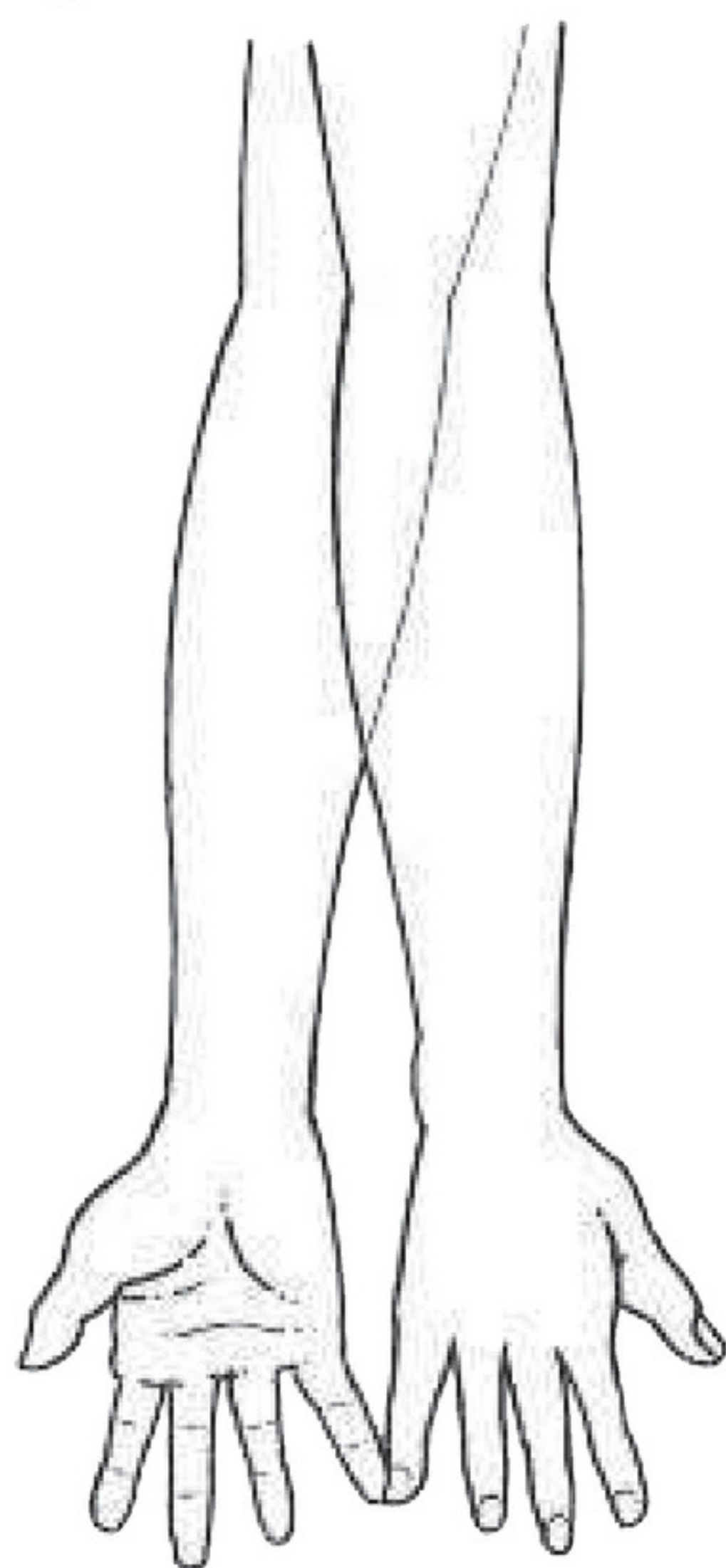
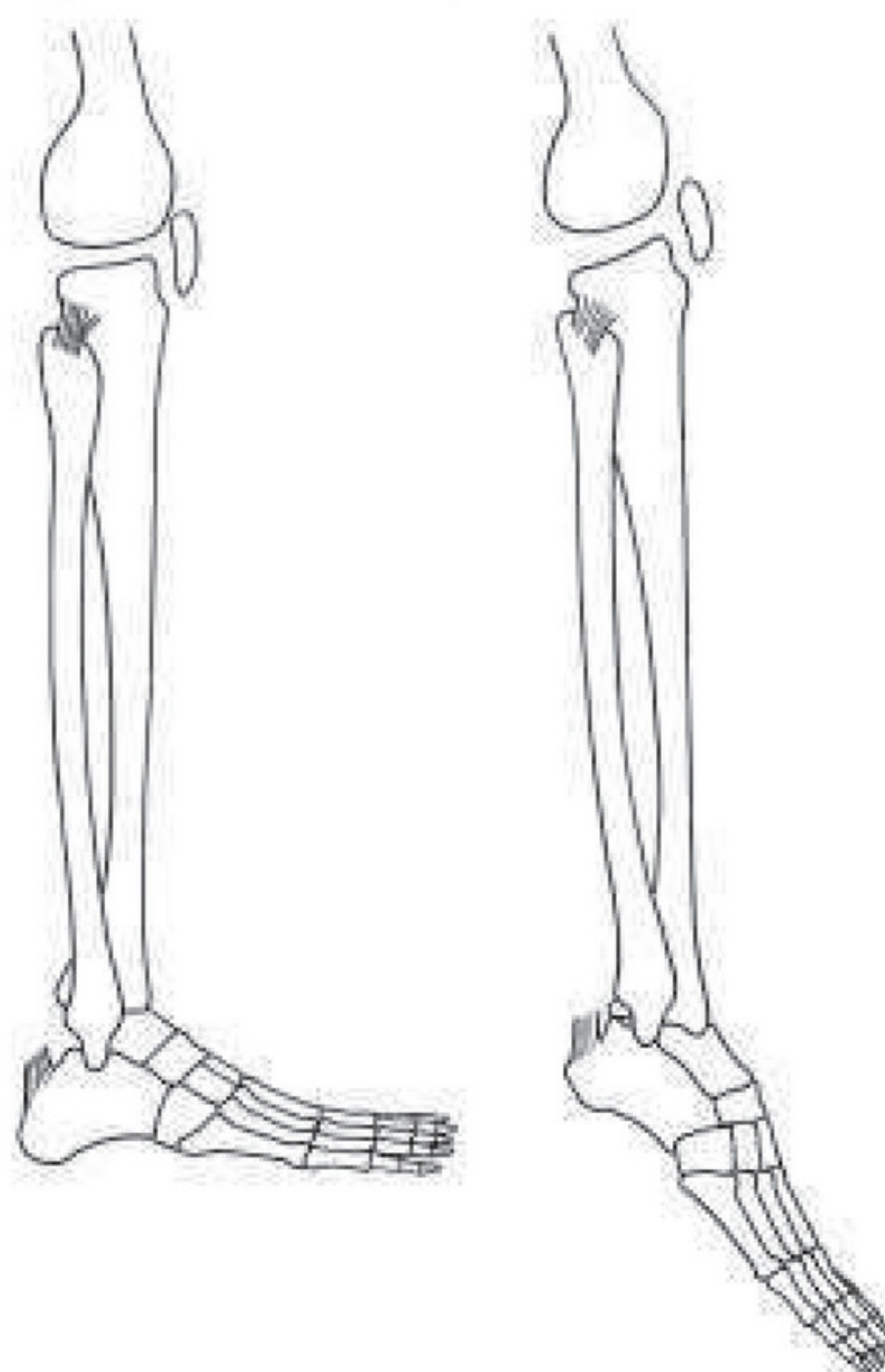
Figure 9 shows an X-ray of a hand and wrist with a bone that has come loose.

- a The bone that has come loose is called the
- b The bone that has come loose is part of the wrist joint, which is a type called an 'ellipsoid joint'.
Explain this by describing the movements your wrist can make.

8

Figure 10 shows a movement of the forearm.

- a Which type or types of joints can you find in your elbow?
ball-and-socket joint / pivot joint / hinge joint
- b A type of joint found in your arm but not in your leg is the
ball-and-socket joint / pivot joint / hinge joint.
- c Can you make the same movements with your lower leg as with your forearm? Explain your answer.
- d Figure 11 shows drawings of the foot in two positions.
The joint that makes these positions of the foot possible is a
ball-and-socket joint / pivot joint / hinge joint.

fig. 10 Movement of the forearm.**fig. 11** A foot in two positions.**+ 9**

The shoulder joint and hip joint both let you make a rotating motion. This lets you move your hand or foot to trace a circle.

- a** You can make the bigger circle with your *hand / foot*.
- b** Touch the top of your shoulder. The bone you feel there is called the
- c** Read the text about 'Information from a physiotherapy practice' in figure 12 and look at the X-ray.
In the figure, label the *acromion process – ball-and-socket joint – sliding joint*.
- d** Compare the photo to the X-ray of the hip in figure 8. If possible, also look at the shoulder joint and hip joint in a model of a skeleton.
What is it that allows more movement, in more directions, in the shoulder than in the hip? Give two explanations.

**fig. 12****Information from a physiotherapy practice**

The shoulder has two joints that work together:

- the joint between the collarbone and the tip of the shoulder (acromion process); this is a gliding joint;
- the joint between the humerus and the shoulder blade; this is a ball-and-socket joint.



HOW IT FITS TOGETHER the living world

HYPERMOBILITY: A DISEASE OR A BLESSING?

Some people can bend their thumbs back so far that they can touch their forearm, or they can bend their elbow inwards as well as outwards (see figure 13). Hypermobility can be the result of a disease, but it usually just means that person is a lot more flexible than the average person. Hypermobile joints can sometimes cause problems. There is a big risk of wear and tear in the joints, painful effusion (fluid building up), the bone coming out of the socket and other injuries.

But flexibility has advantages as well as disadvantages. Hypermobility is relatively common among musicians, gymnasts and ballet dancers, for example. In some countries, hypermobile children are selected at a young age for training to become top gymnasts.

fig. 13 A boy with a hypermobile joint.



10

Read the text about 'Hypermobility, a disease or a blessing?' and look at figure 13.

- a** Work out what movements you can make with your elbow joint.
What is the difference with the boy's elbow?
- b** Hypermobile joints are more flexible but not as strong as 'normal' joints.
Which parts of a joint are not as strong in hypermobility?
- c** In hypermobility, there is a greater risk of wear and tear in the joints because the joint's bones rub against one another more often.
Which part of a joint gets the most wear and tear?
- d** Children with hypermobile fingers often have poor handwriting and cannot draw very well.
Explain why.

 Go to the *Flash cards* and the *Test yourself* section.

4 Muscles

LEARNING OBJECTIVES

4.4.9 You can explain how the muscles work.

4.4.10 You can give examples of voluntary and involuntary muscle movements.

► Learning how to do research 1 and 2

► Practical activity 3

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES			
	4.4.9	4.4.10	4.2.4*	4.3.6*
Remembering	2ac			
Understanding	1, 2bd, 4, 5a, 6a	3, 4		
Using	5bc, 6b, 8a, 9d		9bc	9bc
Analysing	5d, 7, 9ae	8bc		

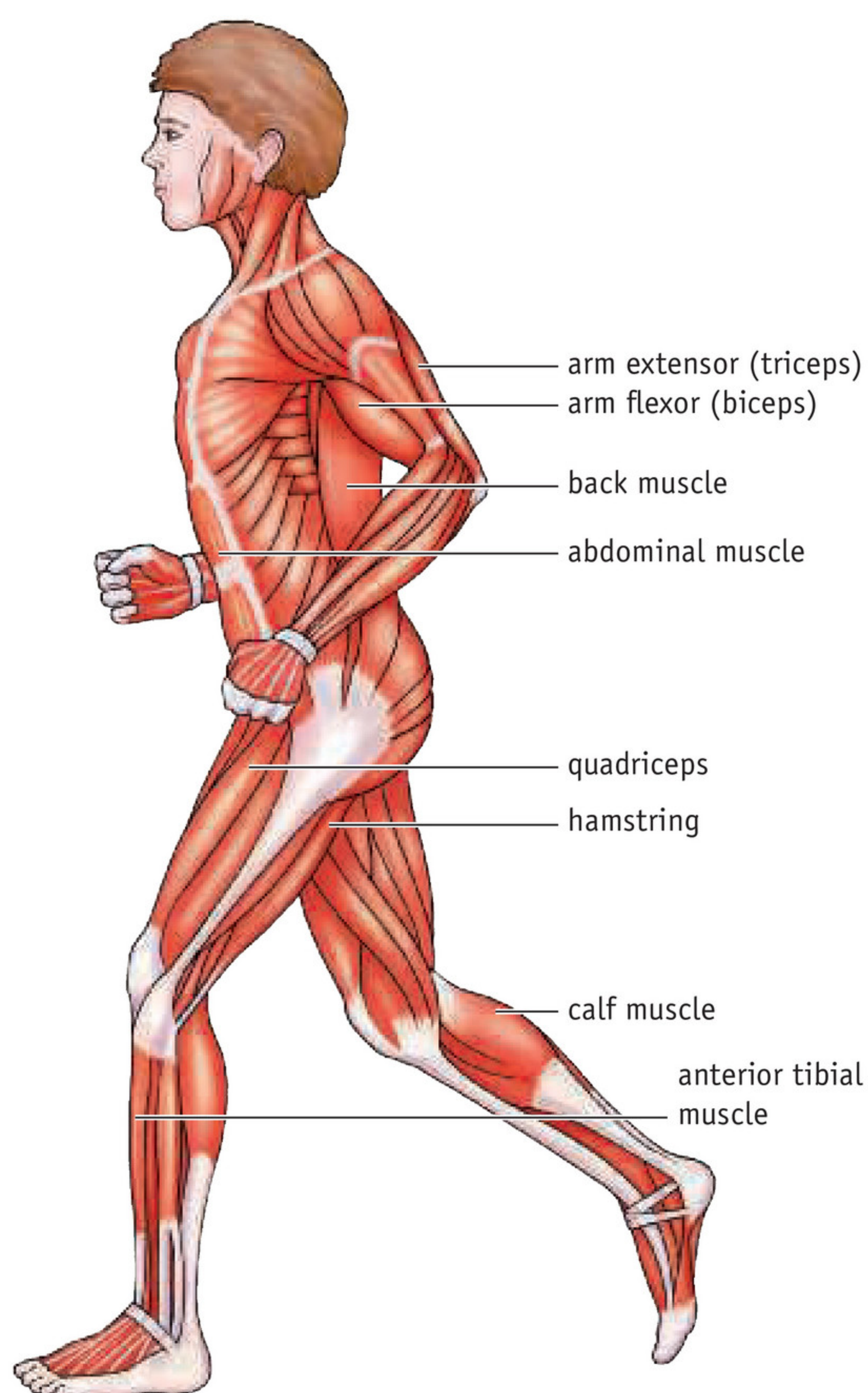
*You can find this learning objective in another Basics section.

Bones can't move of their own accord. To move them, you need muscles. There are muscles in other parts of your body too.

MUSCULAR SYSTEM

Muscles are attached to the bones. These muscles let you stand up straight and move about. All the skeletal muscles in your body combined form the **muscular system** (see figure 1).

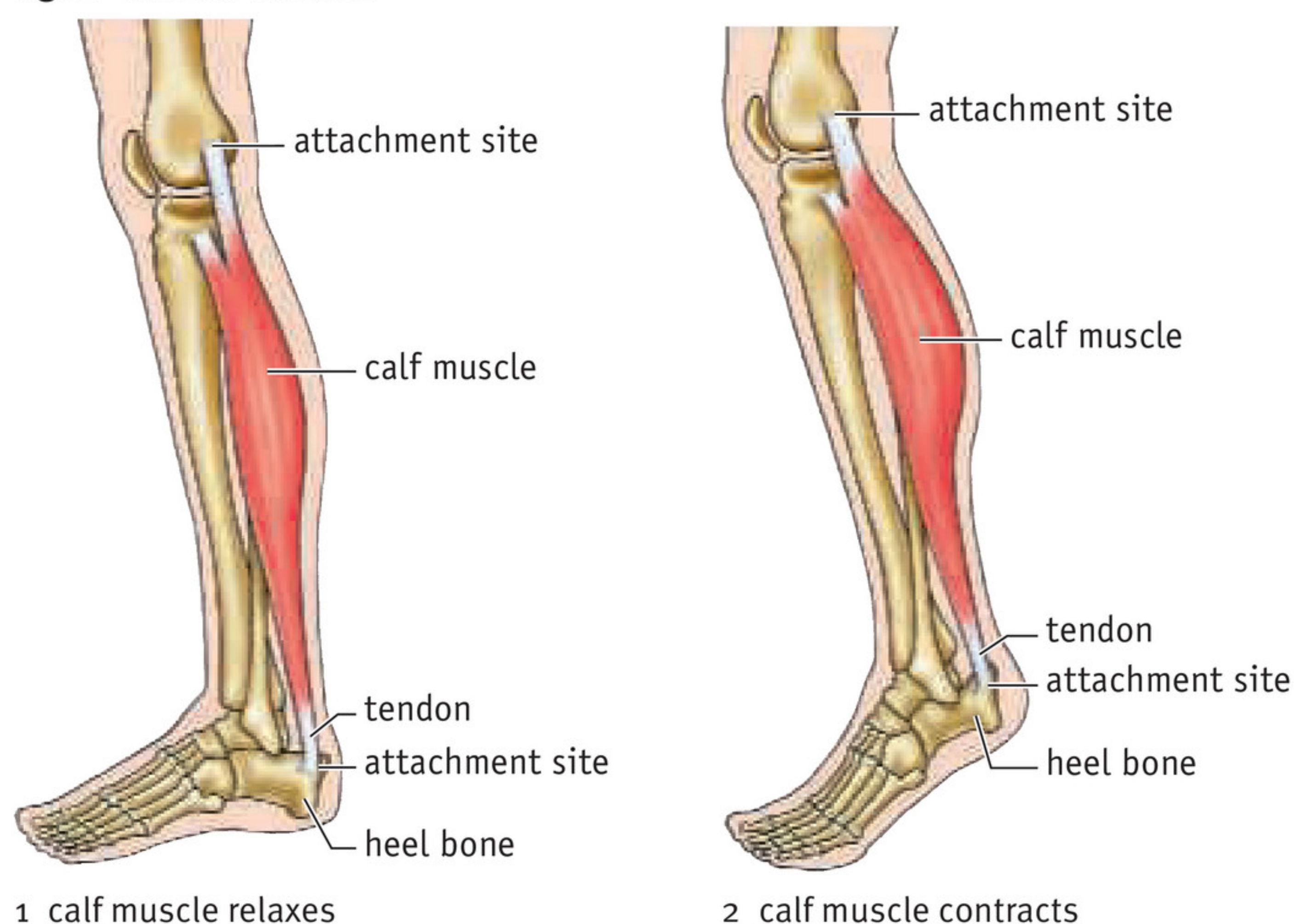
fig. 1 The muscular system.



TENDONS

The muscle is attached to the bone by **tendons**. The point where the tendon is attached to the bone is called the **attachment site** (see figure 2). Muscles are able to contract, but tendons are not. When a muscle contracts, it becomes shorter and thicker. As a result, the muscle pulls on the bones that it is attached to. The muscle pulls the bones towards each other. This is how movement occurs. Figure 2 shows how this works for the calf muscle. When the calf muscle contracts, the heel bone is raised.

fig. 2 The calf muscle.



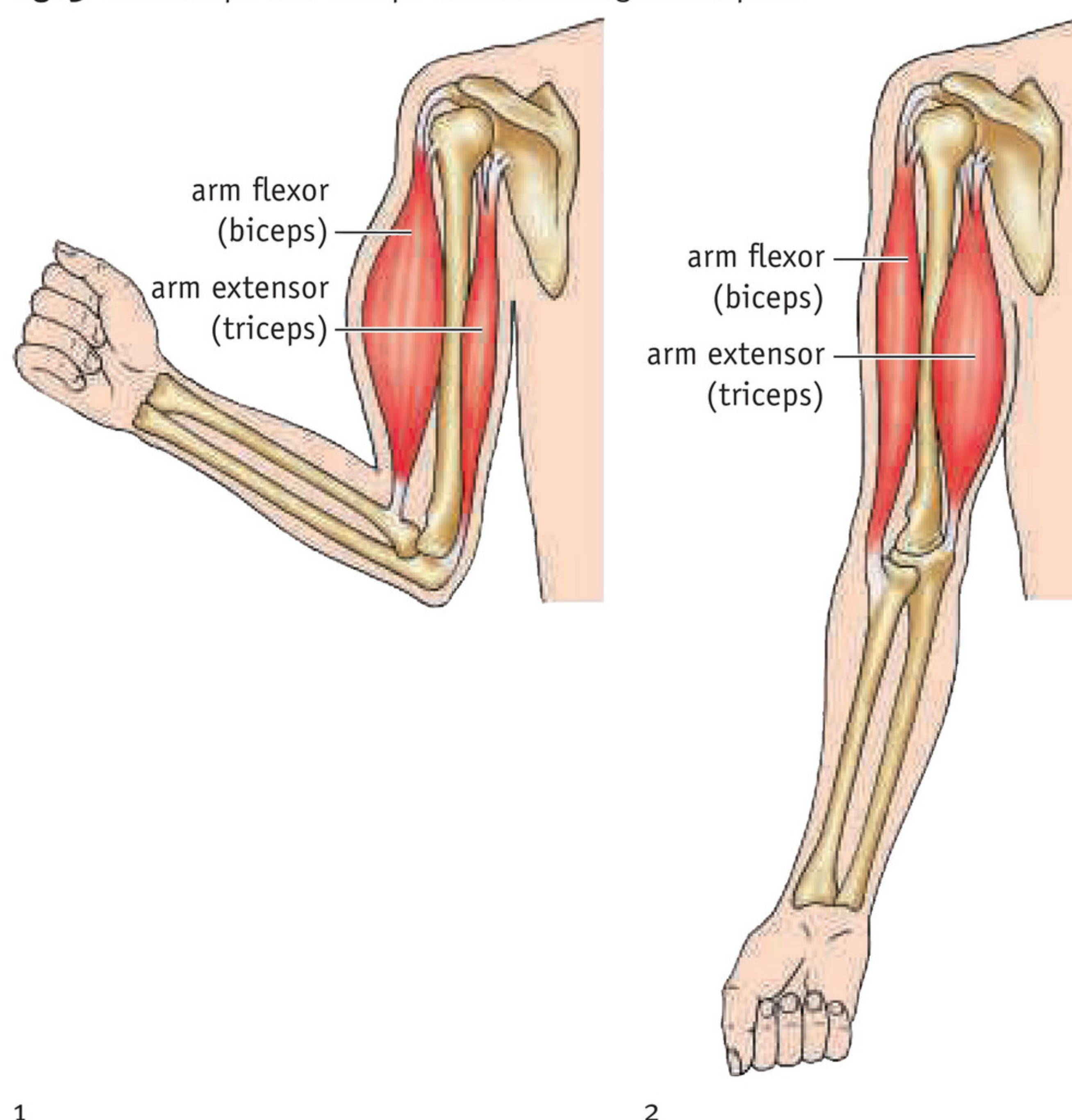
ANTAGONISTIC PAIR

Figure 3 shows the muscles that move your forearm. You need two muscles to move your forearm: the **biceps** (arm flexor muscle) and the **triceps** (arm extensor muscle).

The arm is bent in figure 3.1. The biceps is then contracted. The biceps pulls on the radius, which makes the arm bend. The biceps can't push the bone back, so to stretch the arm again you need the triceps. When this muscle contracts, it pulls on the ulna and the arm stretches out (see figure 3.2).

To move a bone, you always need two muscles: a flexor muscle and an extensor muscle. These two muscles have opposite effects. The flexor muscle and extensor muscle that combine to make one movement possible are called an **antagonistic pair**. The extensor muscle is the antagonist of the flexor muscle.

fig. 3 The biceps and triceps form an antagonistic pair.



OTHER MUSCULAR MOVEMENTS

In addition to the skeletal muscles, you also have muscles in your organs. These **organ muscles** move without you being aware of it. Examples are the muscles in the wall of the oesophagus, the stomach and the intestines. When you eat, these muscles move the food through the digestive tract.

Your heart is also a muscle: the cardiac muscle. When it contracts, your heart pumps blood through the body. You even have muscles in your skin. There is a tiny muscle attached to each individual hair. When you get goosebumps, all those little muscles contract.

KNOWLEDGE

1

- a** Are muscles in the intestines part of the muscular system? Explain your answer.
- b** If you bend your arm, then:
 - ☐ A only the biceps contracts.
 - ☐ B only the tendon contracts.
 - ☐ C both the biceps and the tendon contract.
- c** Why do you get movement when a muscle contracts?
- d** When a muscle relaxes, it becomes *shorter / longer* and *thicker / thinner*.

2

- a** What is an antagonistic pair?
- b** Why do you need an antagonistic pair for each motion?
- c** The antagonist of the biceps is the
- d** The antagonist of the calf muscle is the

3

You can move your thumb voluntarily but not your cardiac muscle.

- a** Write down three muscles that you don't move voluntarily.
- b** Muscles that you don't move voluntarily are *organ muscles / skeletal muscles*.
- c** You move skeletal muscles *voluntarily / involuntarily*.
- d** Most organ muscles *are / are not* attached to your bones.

4

**Summary**

Make a summary of this basic course material, for example using a word web. Use at least the following terms: *antagonistic pair – voluntary – bones – flexor muscle – cardiac muscle – involuntary – organ muscles – tendons – skeletal muscles – muscles – muscular system – extensor muscle*.

INSIGHT

5

Take hold of your left forearm with your right hand. Make a fist with your left hand, then stretch out your fingers.

- a** The muscles you use to move your fingers are *in the upper arm / in the hand / in the forearm*.
- b** To bend over forwards, you tense your muscles. To stand back upright after bending forwards, you tense your muscles.
- c** When a muscle contracts, its antagonistic muscle relaxes. Explain why.
- d** Do you always need your triceps to straighten your arm again? Explain your answer.

6

The arm flexor muscle is also known as the biceps and the arm extensor muscle is called the triceps.

- a** Think of another name for the calf muscle.
- b** Figure 4 shows a footballer who is about to kick a ball. Just before he kicks the ball, the *hamstring / quadriceps* in his right leg is contracted. When he kicks the ball, his *hamstring / quadriceps* is contracted.

fig. 4 A footballer.



7



Arthropods such as crabs (see figure 5) can also move parts of their skeletons using joints.

Figure 6 shows the leg joint of a mammal and figure 7 shows the leg joint of an arthropod. Muscle P is contracted and muscle Q is relaxed.

- Draw in the antagonist to muscle P. Think about the thickness of the muscle. The tendons have already been drawn in.
- Draw in the antagonist to muscle Q.

In drawing 6.2, the leg of the mammal is straight.

- Draw the muscles for this leg. Think about the thickness of the muscles.

In drawing 7.2, the leg of the arthropod is straight.

- Draw the muscles for this leg.

fig. 5 A crab.



fig. 6 Leg joint of a mammal (bent and straight).

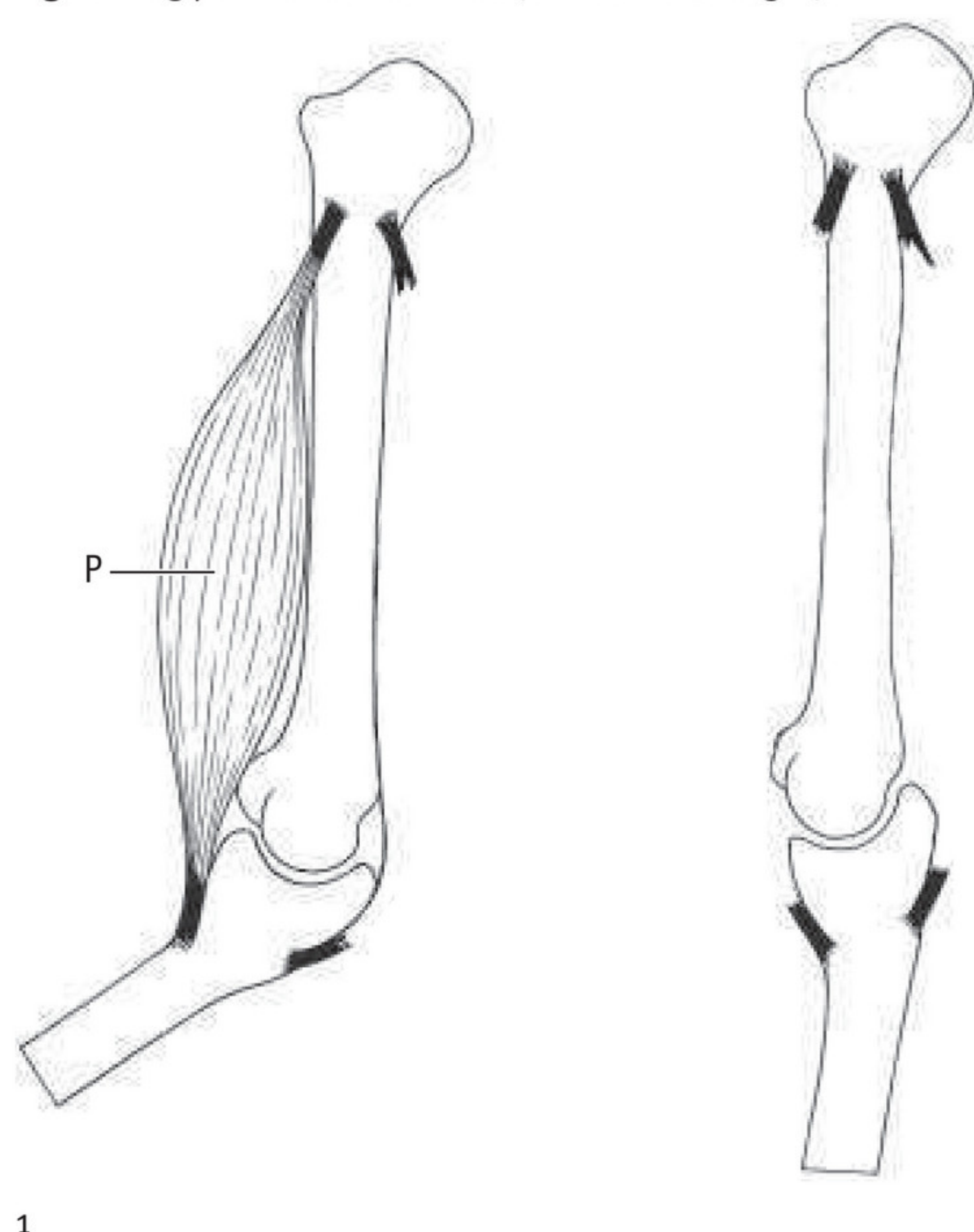
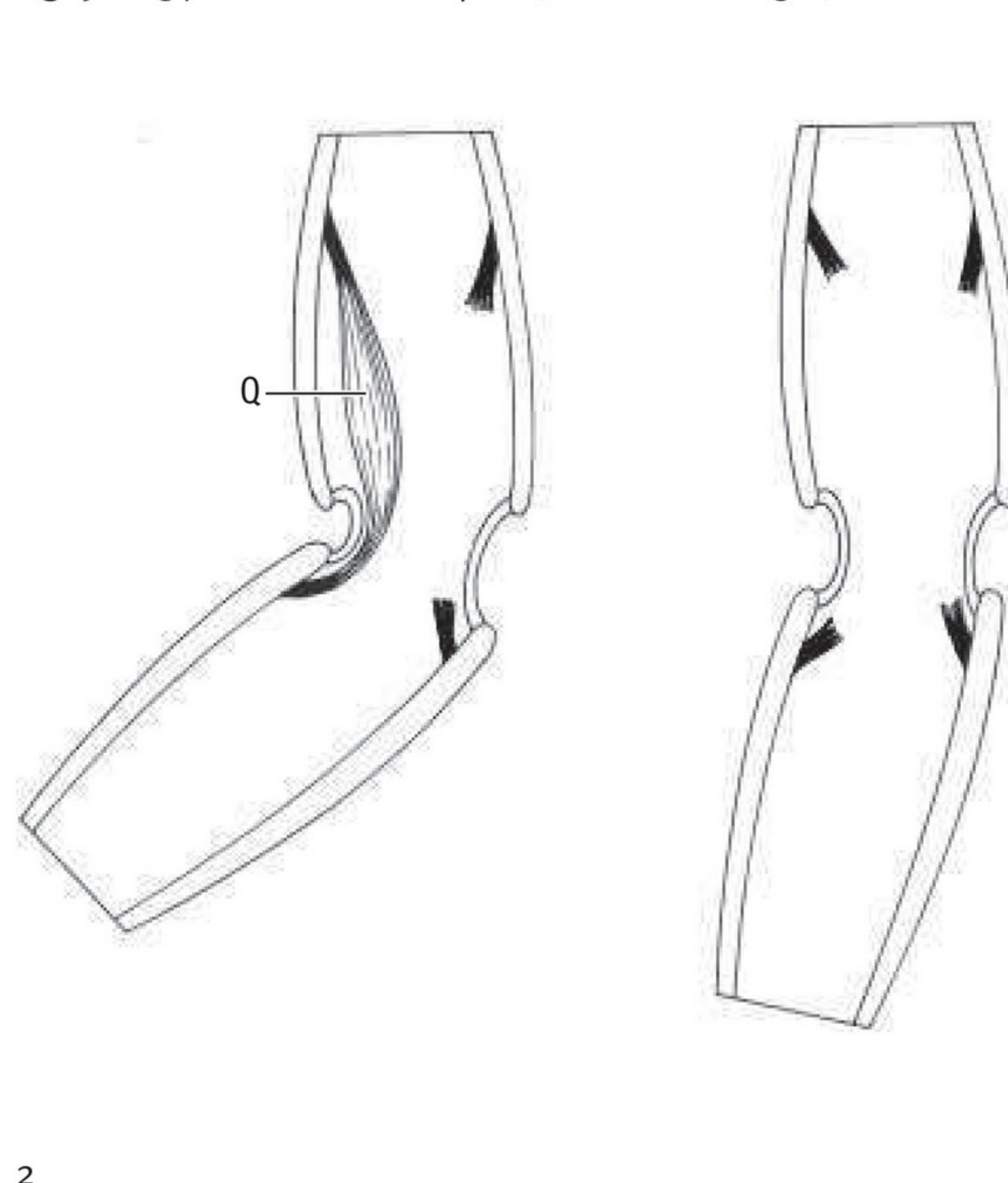


fig. 7 Leg joint of an arthropod (bent and straight).

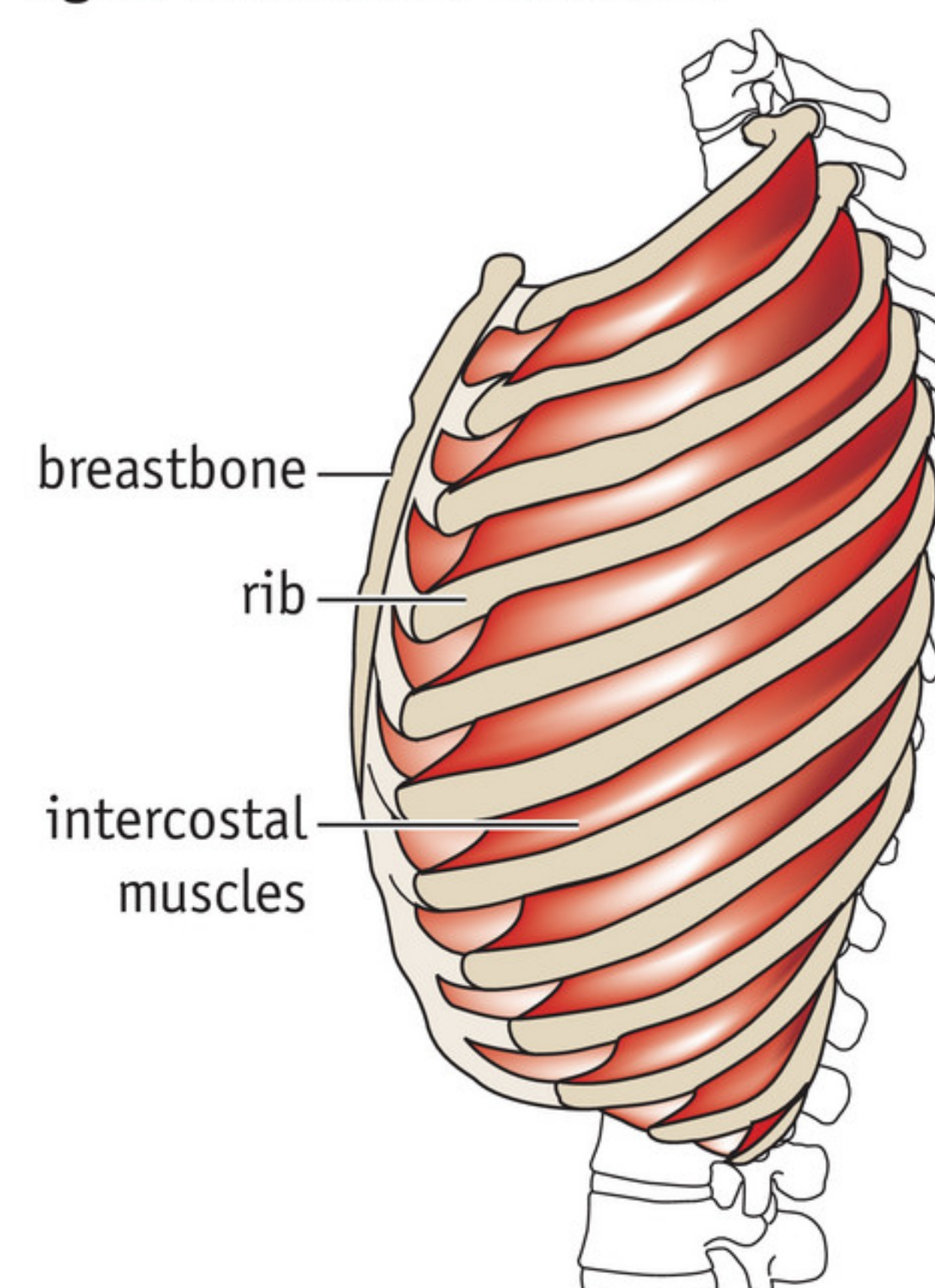


+ 8

Figure 8 shows the intercostal muscles (between the ribs). You use these muscles when breathing.

- Are the intercostal muscles skeletal muscles? Explain your answer.
- You can use the skeletal muscles to make voluntary movements.
Is breathing a voluntary movement? Explain your answer.
- The intercostal muscles have the same structure and function as skeletal muscles. Despite this, they are classed as muscles for involuntary movement. Explain why.

fig. 8 Intercostal muscles.



HOW IT FITS TOGETHER profession

PHYSIOTHERAPIST AND MANUAL THERAPIST

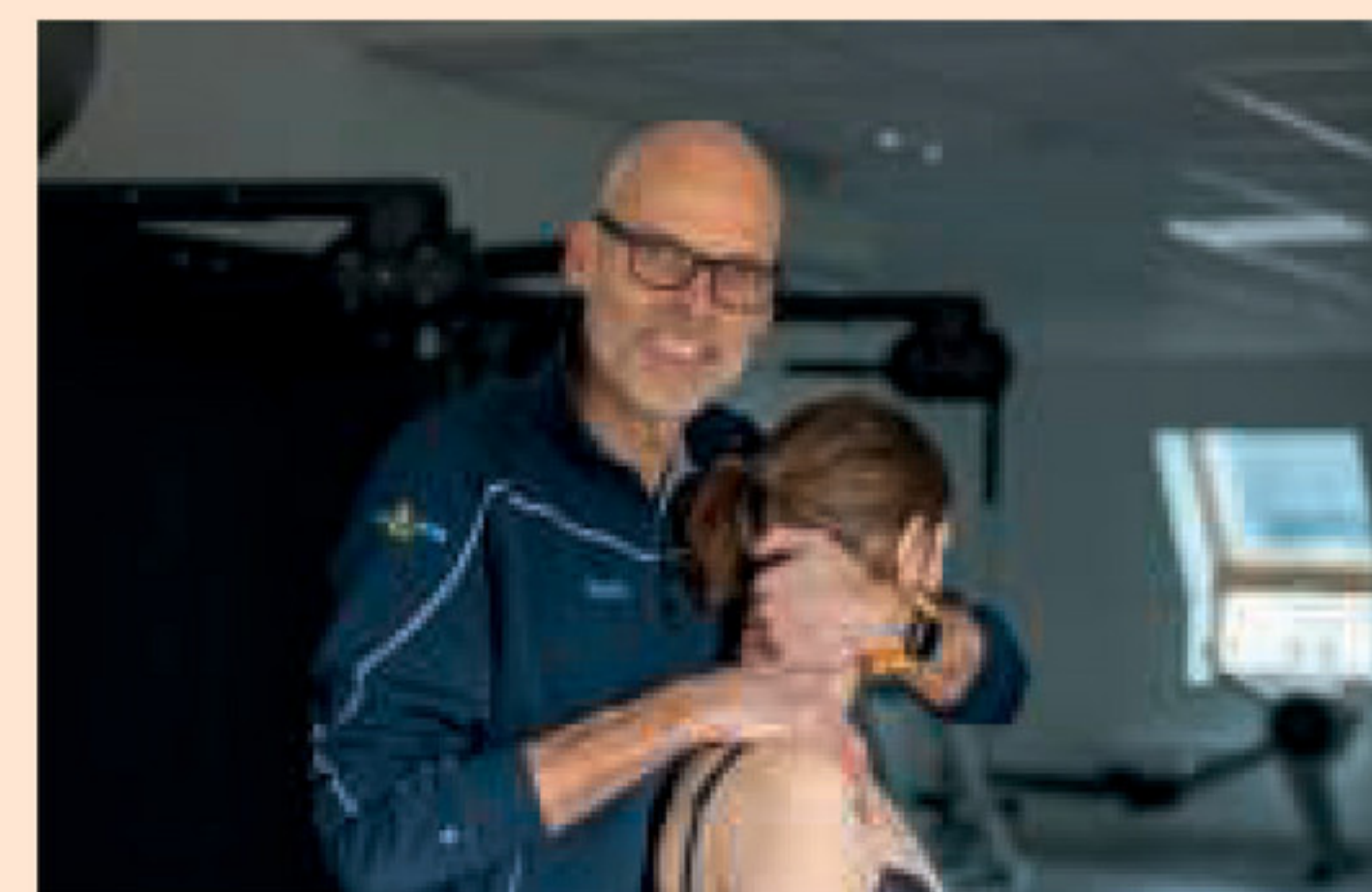
Marijn Michels is a physiotherapist and manual therapist in the Fysiohuis practice in Bunschoten. “Physiotherapy focuses on the softer parts of the body: the muscles, tendons, capsules and ligaments, and on problems with the knee or shoulder, for instance. I treat athletes, for example by massages. The constant movement and pressure in a massage makes their muscles flexible again and reduces the pain. I also give them advice about training. Sometimes I get patients to do exercises on a *balance board* to exercise certain muscles.

An example of an exercise might be:

Stand in front of the balance board. Put your left foot on the balance board first and then the right foot. Get your balance and make sure the edges of the balance board don't touch the ground. Keep your back straight during the exercise and put your hands on your hips.

Manual therapy is a specialist field within physiotherapy. It focuses mainly on the harder parts of the musculoskeletal system, especially the spinal column. Not being able to move very well is often associated with pain and stiff joints. That in turn often affects the posture. The aim of manual therapy is to get the joints moving better on the one hand and to improve the posture and movement on the other.”

fig. 9 Marijn Michels.



9

Read the ‘Physiotherapist and manual therapist’ text.

- a Which muscles are *not* used in the exercise with the balance board?
 - ☐ A hamstring
 - ☐ B biceps
 - ☐ C gluteal muscles
 - ☐ D abdominal muscle
 - ☐ E calf muscle
 - ☐ F back muscles
 - ☐ G triceps
 - ☐ H quadriceps
- b Manual therapy is mainly useful when you have problems with the harder parts of your musculoskeletal system.
Which parts are those?
- c Which parts of a joint are stiff when a joint is not able to move smoothly?
- d The Achilles tendon connects the calf muscle to the heel. This tendon can rupture (tear). To find out whether an athlete has torn their Achilles tendon, Marijn does a test. He gets the patient to kneel on a massage table with the foot hanging down. Then he pinches the calf muscle.
Will the foot move if the Achilles tendon is ruptured? Explain your answer.
- e Explain how the calf muscle shifts towards the back of the knee if the Achilles tendon is torn right through.

 Go to the *Flash cards* and the *Test yourself* section.

5 The spinal column

LEARNING OBJECTIVE

4.5.11 You can say what a good posture is and why that is important.

- ▶ Learning how to do research 3
- ▶ Practical activities 4 and 5

TAXONOMY	LEARNING OBJECTIVE AND EXERCISES			
	4.5.11	4.1.2*	4.1.3*	4.4.9*
Remembering	1abcd, 3			
Understanding	1e, 2, 4			
Using	5, 6abc, 7	8c		
Analysing	6d, 8a, 9, 10abc		8b	8b, 10b

*You can find this learning objective in another Basics section.

A good posture reduces the risk of complaints. The spinal column and the back muscles then work together.

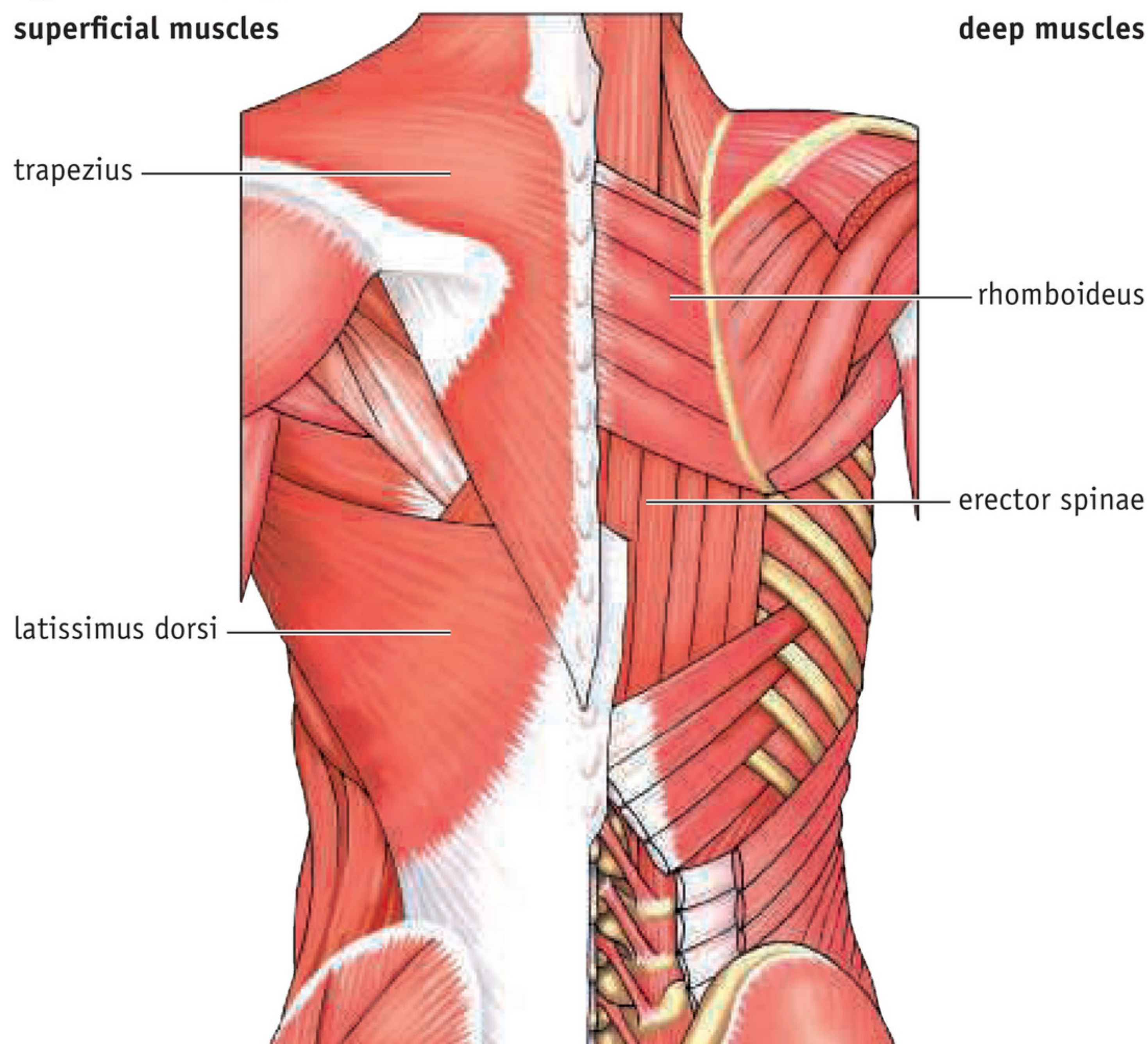
DOUBLE S-SHAPE

The spinal column is made up of over 30 vertebrae, 24 of which can move with respect to one another. The shape of the backbone looks like two letter S's, one above the other (see the blue lines in figure 1). This shape is therefore called a **double S-shape**. This shape is maintained by the back muscles, which are connected to the vertebrae (see figure 2).

fig. 1 Double S-shape.

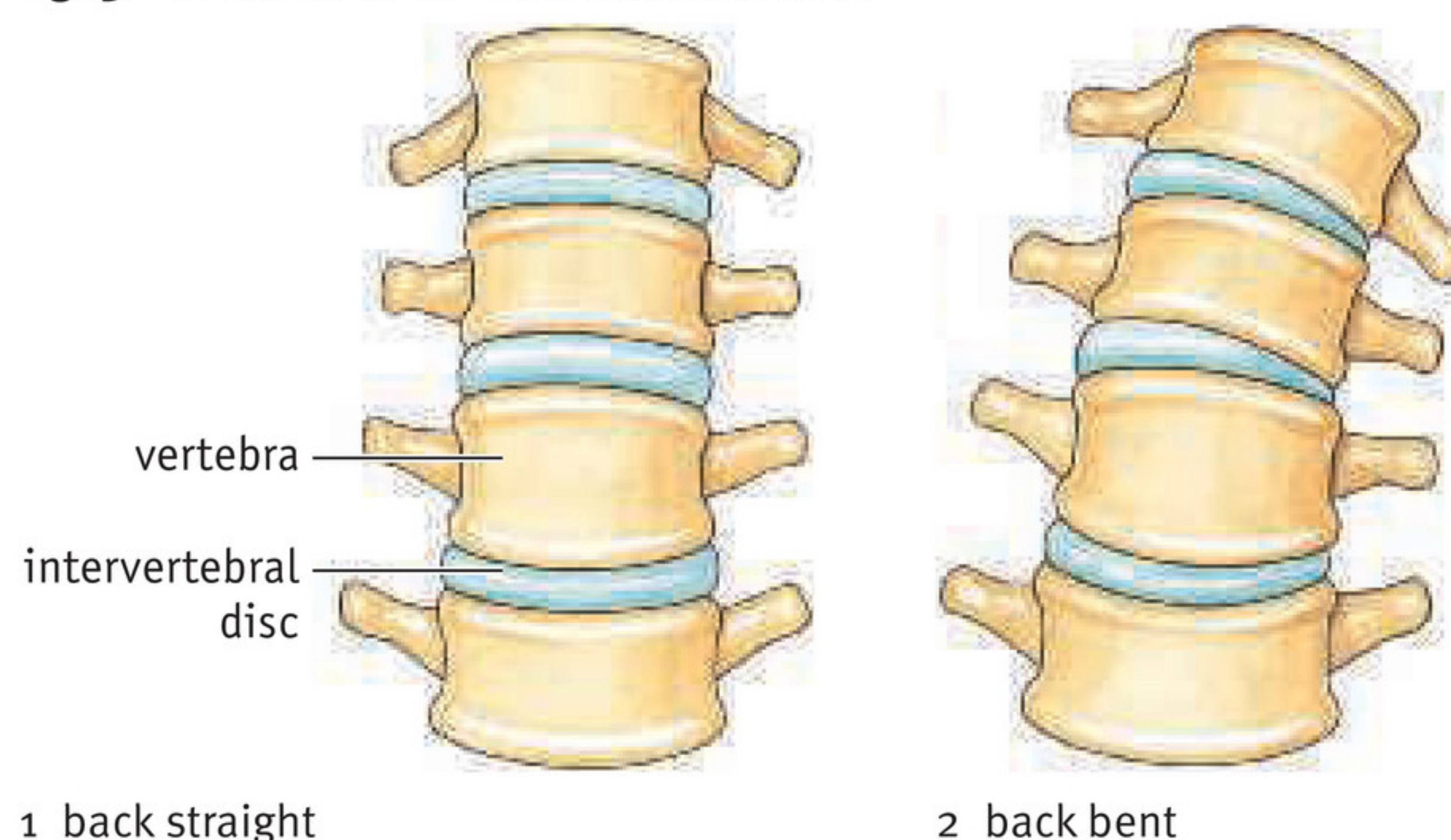


fig. 2 Back muscles.
superficial muscles



The vertebrae are connected together by cartilage. The discs of cartilage between your vertebrae are called the **intervertebral discs** (see figure 3). The intervertebral discs act as a kind of shock absorber and also make it possible for the spinal column to bend. An intervertebral disc consists of a **gelatinous core** that is surrounded by cartilage. Above all, this pulpy core is what gives an intervertebral disc its springiness.

fig. 3 Vertebrae and intervertebral discs.



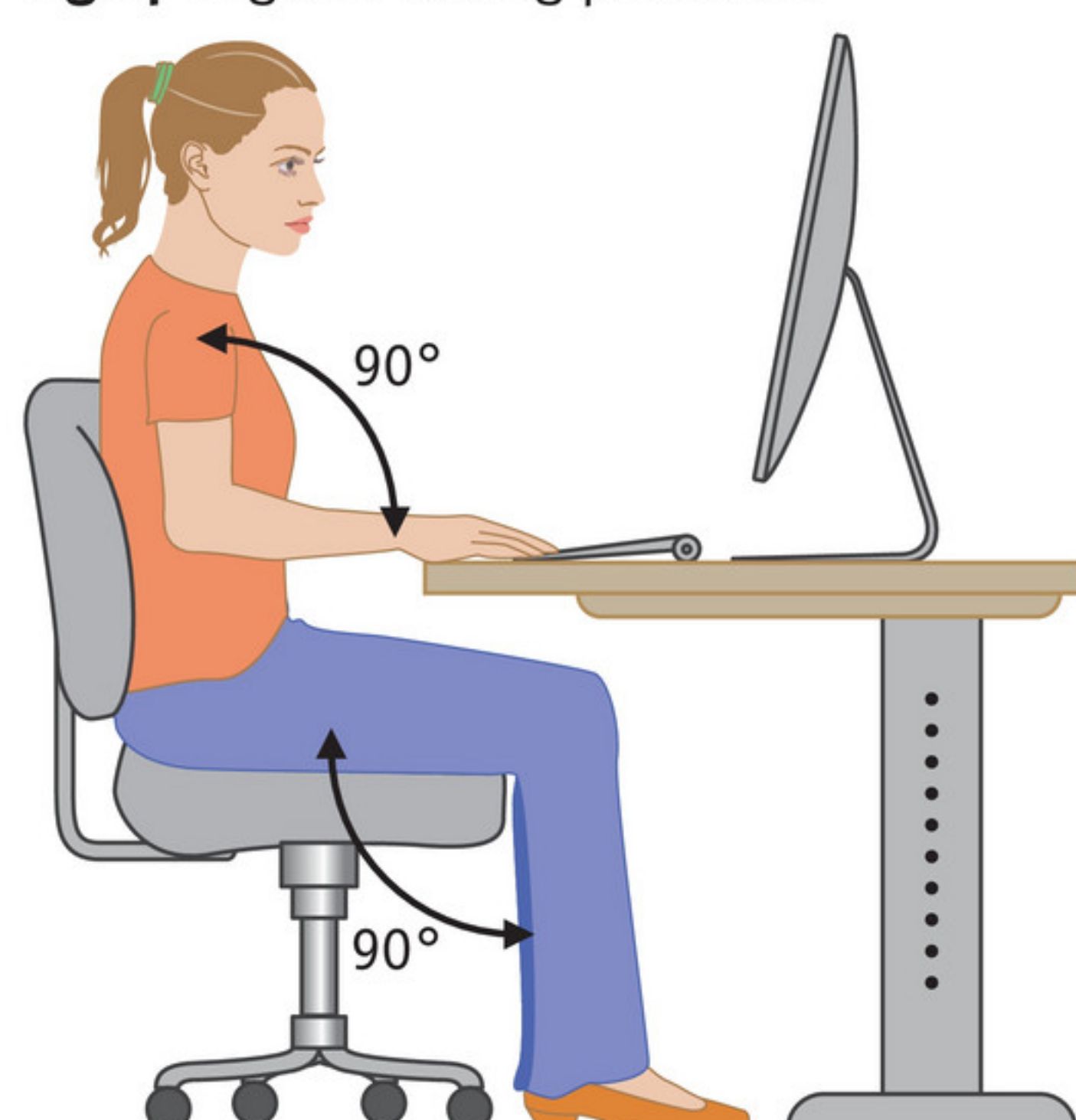
POSTURE

Your position when you are standing or sitting is called your **posture**. If you have good posture, your back is straight. Your spinal column then has a double S-shape. Your posture develops when you are young. It is difficult to change your posture later, when you are older.

If you have good posture, it helps you move better. Good posture prevents uneven stress on the back muscles and intervertebral discs, which can cause back complaints. What is more, good posture can give you more self-confidence.

Incorrect posture can be painful, for example in your back or shoulders. If you work at a table, the positions of your arms and legs are also important. Figure 4 shows a good **sitting position**. The arms and legs form right angles.

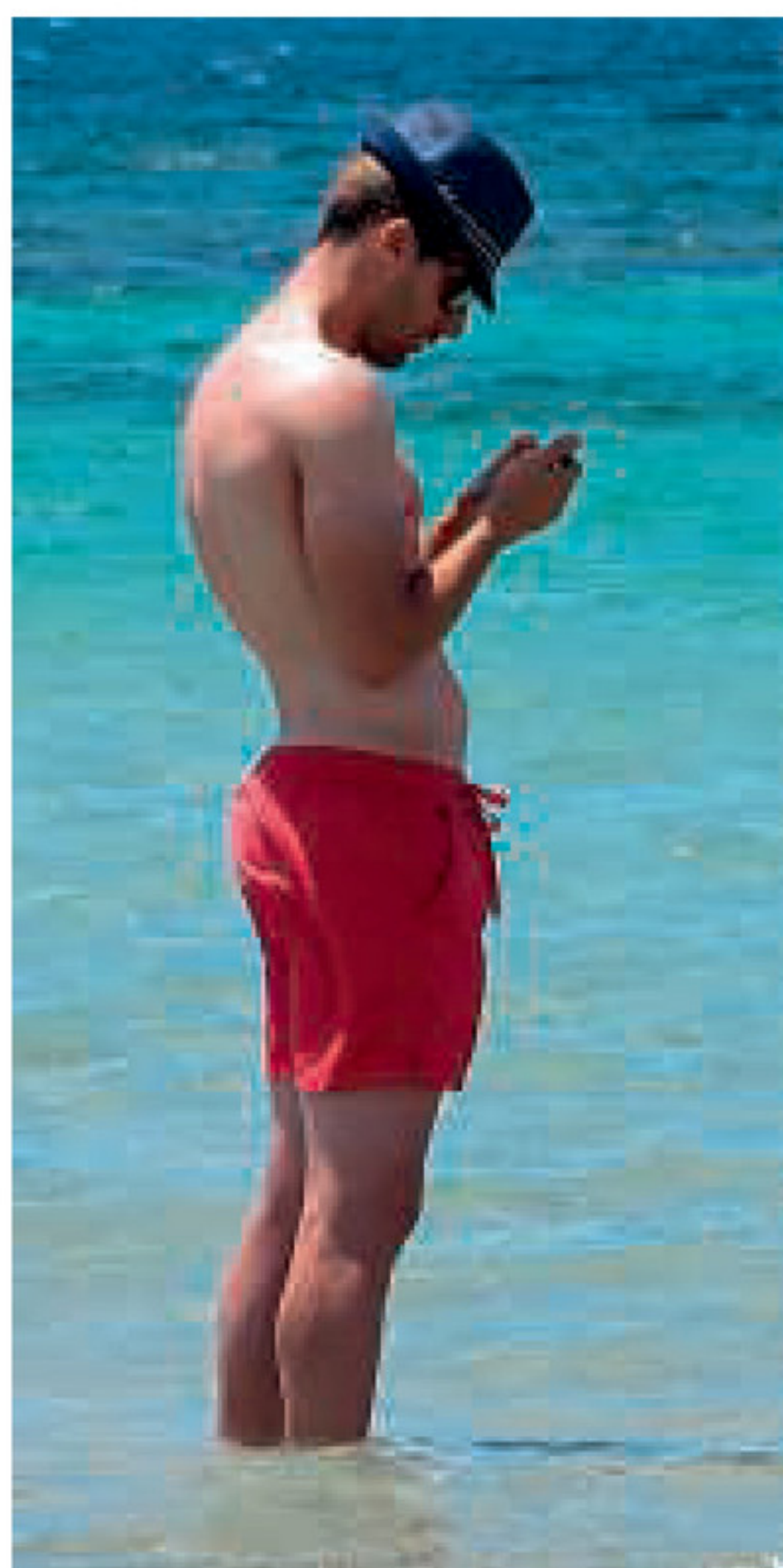
fig. 4 A good sitting position.



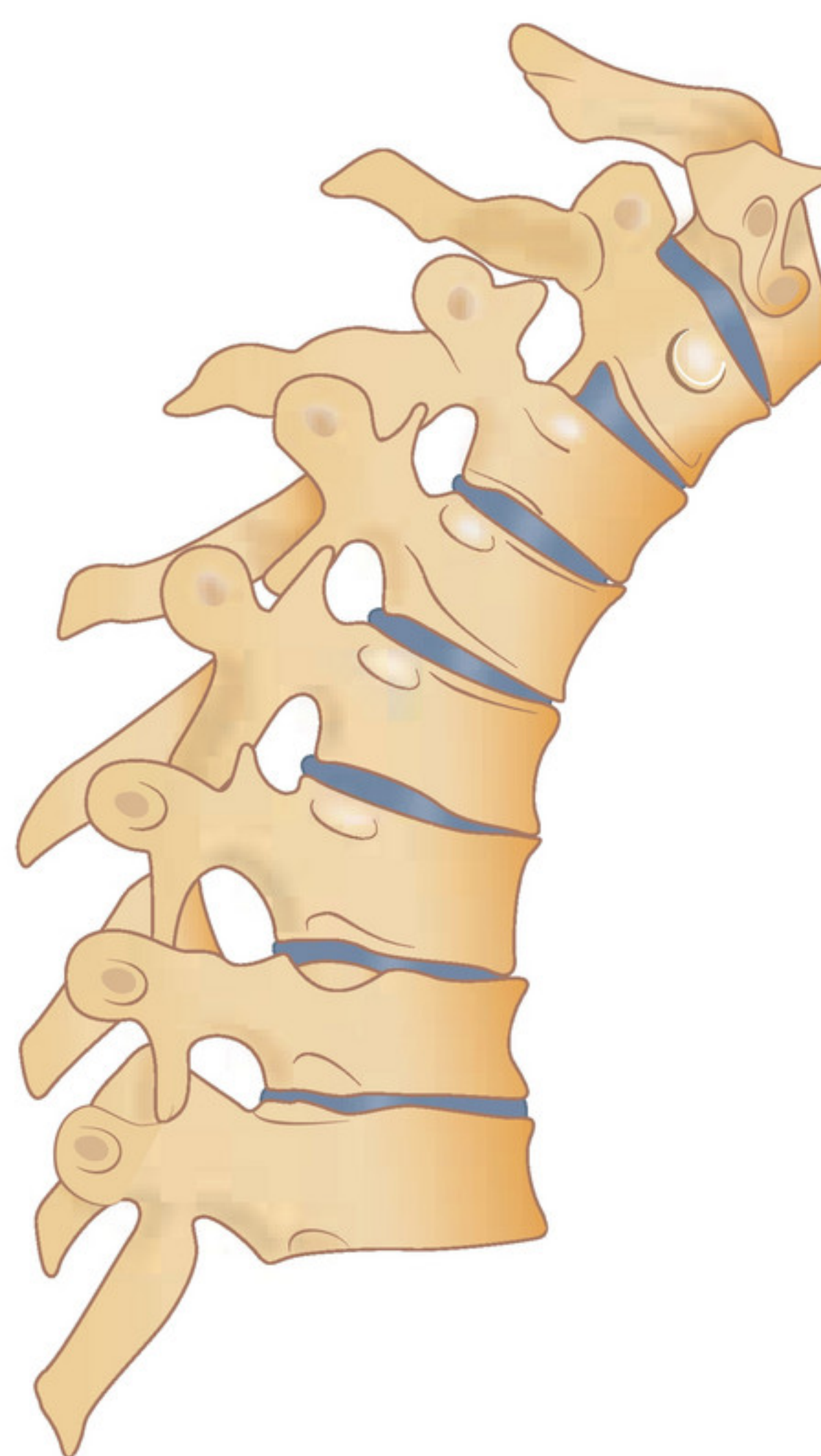
USING SCREENS

When you use a phone, tablet or game console, you often look down at it (see figure 5.1). If you always look at your screen with your head bent, you can develop a **hunch**. A deformation like that even gets called a ‘Gameboy back’ or ‘tablet neck’. The intervertebral discs are pressed together too much on one side (see figure 5.2), which means they lose their elasticity and the back grows bent. It is better to keep your head up straight with the screen in front of you. Figure 6 has more tips on good posture when using screens.

fig. 5 Bending your head down to look at your screen is bad for your back.



1



2

fig. 6

Tips for good posture when using screens

- 1 Hold your head up straight. Put the screen upright or hold it in front of you.
- 2 Don't use the screen for more than half an hour at a time. Then spend ten minutes doing something else.
- 3 Lie on your stomach when reading, gaming, watching films or doing other things with your phone.
- 4 Sit at the front of your chair. Stick one foot back so that your knee is pointing to the ground. Switch feet now and then.



LIFTING

You lift things such as your school bag several times a day every day. It is important for the spinal column to keep its double S-shape during lifting too. Figure 7 gives the rules for lifting things correctly.

fig. 7

Ten rules for lifting things correctly

- | | |
|---|---|
| <ol style="list-style-type: none"> 1 Don't bend and lift if you don't have to. 2 Use aids. 3 Do not lift too much at once. 4 Make sure nothing is in your way when you start walking with your load. 5 Always stand straight in front of the load. 6 Never lift when your back is twisted. 7 Use both arms when lifting and keep the load as close to your body as possible. | <ol style="list-style-type: none"> 8 Do not bend further forward than you have to and use your leg muscles as well. 9 Don't use outstretched arms to lift and don't lift the load above shoulder height. 10 Listen to your body: take signs of problems seriously. Your back will tell you what it can manage and what it can't. |
|---|---|

KNOWLEDGE

1

- a Which muscles keep the spinal column in its double-S shape?
- b What two functions do the intervertebral discs have?
- c What is meant by 'posture'?
- d Good posture means that the stress put on the back muscles and intervertebral discs is *even* / *uneven*. This leads to *more* / *fewer* back problems.
- e Figure 8 shows the same woman in two different sitting positions. Which is a good sitting position? Explain your answer.

fig. 8 Sitting position.

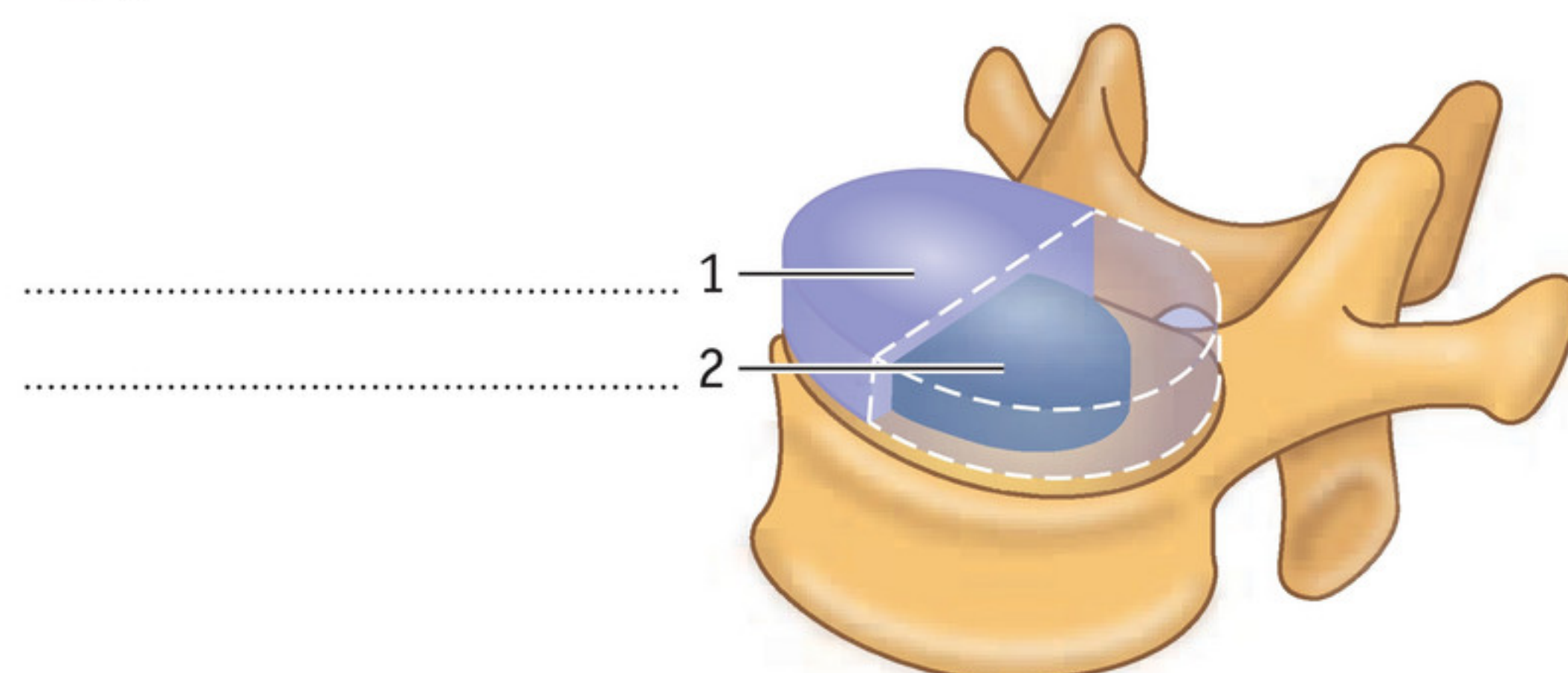


2

Figure 9 shows a schematic drawing of a section of the spinal column.

- a Write down the names of the numbered parts.
- b The discs between the vertebrae are made of
- c The vertebrae have large protrusions. What is the purpose of these protrusions?

fig. 9 Vertebra and intervertebral disc.



3

What are the dos and don'ts for lifting things correctly?

- 1 *Do* / *Don't* bend and lift unnecessarily.
- 2 *Do* / *Don't* use aids.
- 3 Lift *as little* / *as much* as possible in one go.

- 4 Make sure *nothing / not much* is in your way when you start walking with your load.
- 5 Always stand *straight in front of / at an angle to* the load.
- 6 *Always / Never* lift when your back is twisted.
- 7 Use *one arm / both arms* when lifting and keep the load *as close to / as far away from* your body as possible.
- 8 Don't bend further forward than *you are able to / have to* and *never / also* use your leg muscles.
- 9 *Always / Never* use out-stretched arms to lift and don't lift the load *above / below* shoulder height.
- 10 Listen to your *body / common sense*. Your back *will / won't* tell you what it can manage and what it can't.

4



Summary

Make a summary of this basic course material. Do that by answering the questions.

- What shape is the spinal column and what is it made up of?
- What is your posture?
- What makes a good posture?
- What makes a good sitting position?

.....

.....

.....

.....

.....

INSIGHT

5

Figure 10 shows ten drawings of someone lifting loads. Some of the drawings show correct lifting positions and others don't.

Which drawings show the man lifting a load in the wrong way? Explain your answer.

1 / 2 / 3 / 4 / 5 / 6 / 7 / 8 / 9 / 10

fig. 10 Various lifting positions.



1



2



3



4



5



6



7



8



9



10

6

- a** Max has to help his father paint some planks. He puts them on the floor with some old newspapers underneath. He stands next to the planks while he paints them. Is this a good way of working? Explain your answer.
- b** What would it be better for Max to do?
- c** Figure 11 shows a man sweeping the floor. Is this a good way of working? Explain your answer.
- d** Why is a long car journey not good for your back?

fig. 11 A cleaner at work.



7

A lot of dishes need to be washed in a restaurant and that is why many restaurants have a dishwasher.

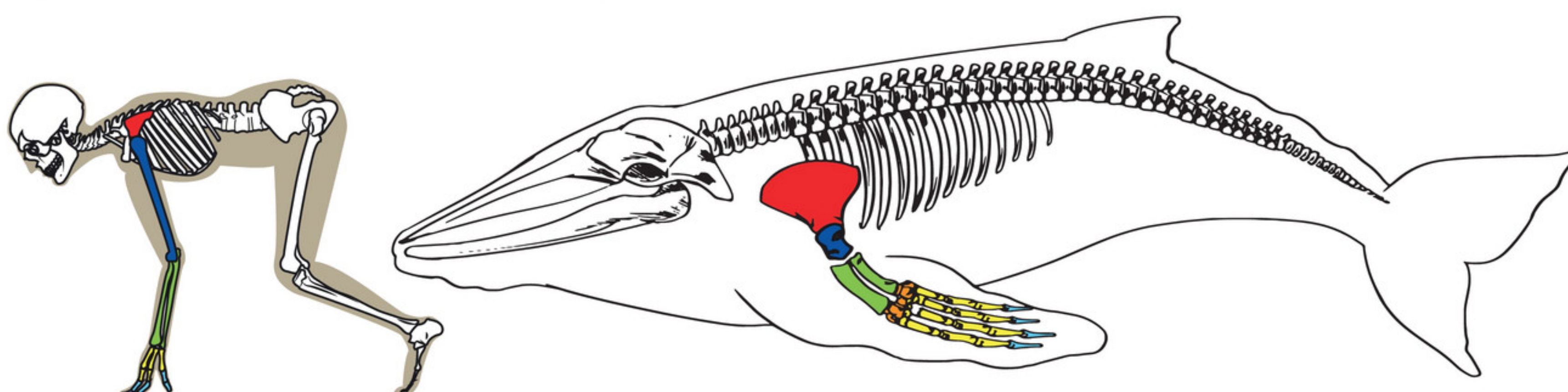
- a** What would be a more sensible choice for the backs of the kitchen staff: to put the dishwasher under the worktop or on the worktop? Explain your answer.
- b** Why is bending over not good for your back, especially when lifting something?
- c** Why is it important to keep your back as straight as possible when lifting things?
- d** Steve has to lift a heavy bookcase. What is the best way of doing this? Explain your answer.

8

Figure 12 shows the skeletons of a human and a sperm whale. The sperm whale is a mammal that lives in the sea.

- a** Explain why the spinal column of a sperm whale does not have a double S-shape.
- b** Why does a sperm whale have thicker bones in its forelegs than humans do in their arms?
- c** Because it swims in water, the sperm whale doesn't have some bones that humans do have. Which bones?

fig. 12 Skeletons of a human and a sperm whale.



+ 9

Figure 6 gives four tips for good posture when using screens.

- a** If you watch television in your living room with a screen mounted on the wall, is it best to do this sitting on the sofa or lying on your stomach on the ground?
Explain which is best.
- b** Which is best if you are watching films on your phone: sitting on the sofa or lying on your stomach? Explain your answer.
- c** You can use tip 4 by sitting at the front of your chair. Stick one foot back so that your knee is pointing to the ground.
Explain why tip 4 gives you a better sitting position.

HOW IT FITS TOGETHER the living world

BACK PROBLEMS

You may associate back problems with older people, but there are actually a lot of young people with back problems. That is because young people spend too much time slouched on sofas rather than moving around and exercising.

If you bend over a lot, slouch when you sit or don't exercise enough, weak spots can develop in the cartilage of the intervertebral discs. If the wrong movement puts a lot of pressure on the core, the gelatinous core can start to leak via that weak spot. This is called a slipped disc (or a herniated disc, more scientifically). The gelatinous substance that is being pushed out presses against a nerve. That causes pain in the back or legs. You can prevent back problems by regularly putting the right kind of strain on your back, for example by walking or cycling. That makes the intervertebral discs stronger and therefore less likely to rupture. Training your abdominal muscles and back muscles also helps prevent back problems.

fig. 13 Back vertebra with a leak from the intervertebral disc.



10

Read the text on 'Back problems'.

The gel in the intervertebral discs is more fluid in young people than in older people.

- a** Explain how this increases the risk of a slipped disc in young people.
- b** A straight back improves the strain put on the spinal column.
Why is it not enough just to train your back muscles?
- c** Explain why most slipped discs occur in the lower back.

 Go to the *Flash cards* and the *Test yourself* section.

6 Healthy exercise

LEARNING OBJECTIVES

- 4.6.12 You know that muscles get stronger through training.
- 4.6.13 You can explain why exercise is good for your health.
- Practical activities 6 and 7

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES			
	4.6.12	4.6.13	4.4.9*	4.4.10*
Remembering	3abc	1ab		
Understanding	3d, 5, 8a	1cd, 2, 4, 5, 8a, 10c	10a	
Using	6a, 7, 8bcd, 9a	7, 8bcd, 10de		
Analysing	6bc, 9bc, 10b		10b	9bc, 10b

*You can find this learning objective in another Basics section.

Exercise is healthy. It makes you fitter and helps prevent problems. You learn how to exercise properly when you are young.

TRAINING MUSCLES

Muscles lose their strength if you don't use them. Muscles that are not used will become thinner and weaker. The opposite happens if you exercise and play sports. If you use your muscles a lot, they become thicker. They can then exert more force. Training makes your muscles stronger.

fig. 1 Exercise by cycling.



EXERCISE

Exercise is not just good for your muscles, it also helps you to relax. That is why a lot of people play sports. Regular exercise is good for your health. Your physical **fitness** improves. That lets you move more easily, for longer and faster.

Exercise is also needed for proper development of motor skills. Exercising enough improves your **coordination**. That means that the various muscles in the body work well together, so that the movements are smooth. The speed and accuracy of your movements also improve with practice and training.

You learn many movements by repeating them lots of times. An example is cycling. Once you have learned it, the movement is stored in your **motor memory**. This form of memory lets you coordinate movements correctly without consciously moving your muscles. Once you have learned how to ride a bike, your body knows exactly what to do without you having to think about it. A movement that you can carry out without having to think is called an **automatic movement**.

MUSCLE PAIN

If you play sports without any training, you may get **muscle pains**. Muscle pain often develops after a movement you are not used to. The unaccustomed strain causes lots of very small areas of damage in the muscles. The more often you train the muscles, the less risk of muscle pain. As the muscles get stronger, they are less likely to get damaged. Trained muscles perform better. You are also less likely to get **injuries** with trained muscles. An injury is damage to a muscle, bone or joint. You can prevent injuries by doing stretching exercises and by warming up and cooling down properly when you play sports (see figure 2).

fig. 2

Warming up, stretching exercises and cooling down

Warming up

Warming up usually starts with running to get warm. For example, football players will run around the pitch a couple of times. Then you do some exercises on the spot. The warm-up makes more blood flow to the muscles. That makes the muscles warmer and they get more oxygen. There should be no more than quarter of an hour between the warm-up and the match or training session. If it is longer, the muscles will cool down again.

Stretching

After the warm-up, you can do a few stretching exercises. Which stretches you should do depends on the sport. Stretching exercises prepare your muscles for the work they are about to do. Good stretching exercises will stretch your muscles gently and gradually. When you do stretches, you move until you can feel a little bit of tension in the muscle, but not so much that it hurts. Bouncing past that point is not good as that actually increases the risk of an injury.

Cooling down

Playing sports causes waste products to end up in your muscles. When you do cooling down exercises, the blood flows faster through your muscles and those waste products are removed. They don't then build up in your muscles.

A cool-down is the reverse of the warm-up. You start with some demanding exercises, then take it more and more gently. A warm shower also helps keep the blood flowing through the muscles.

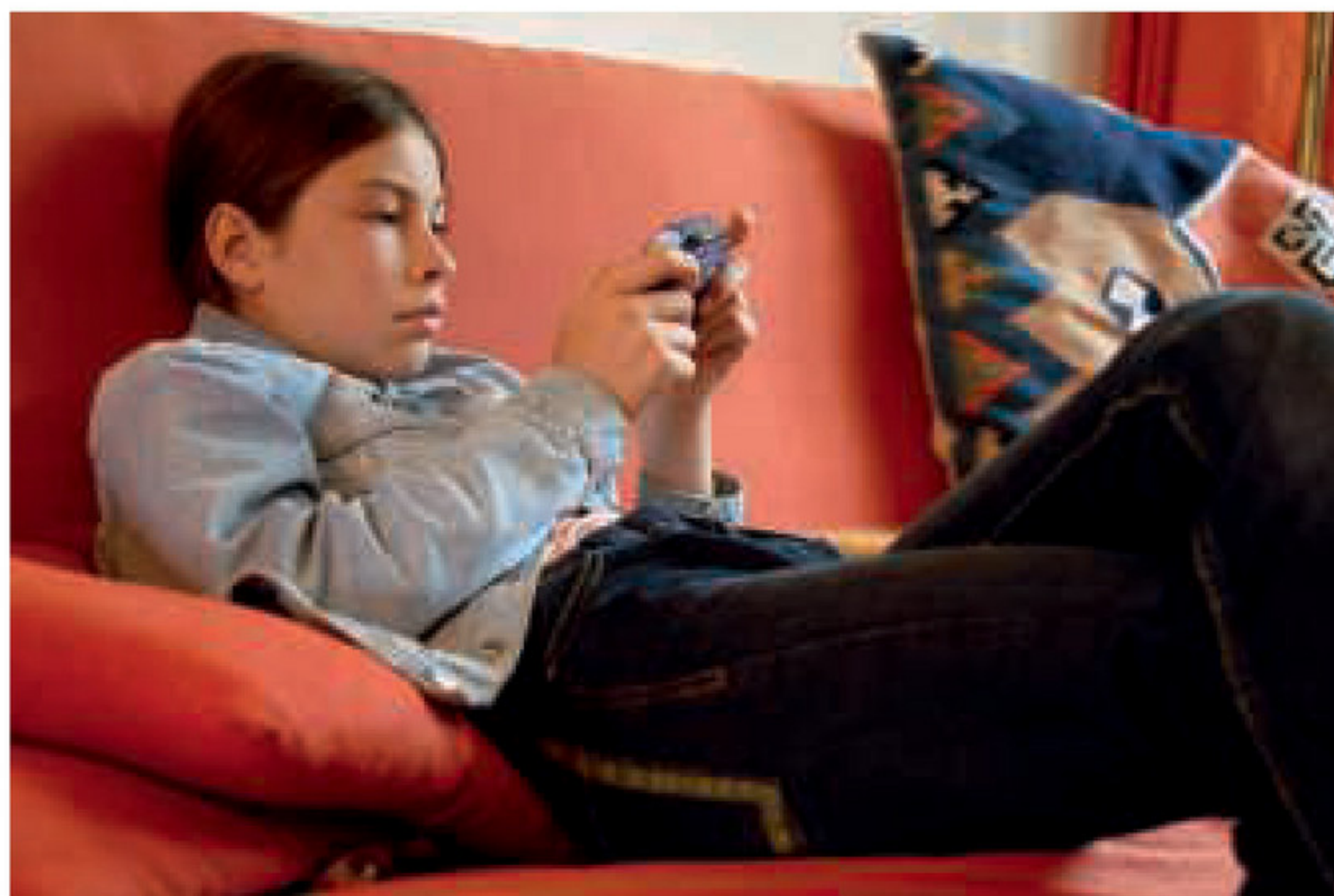
RSI

If you use a phone or play video games for a long time, you may feel pain. That pain is usually in your shoulder, arm or neck. You may get a headache too. The pain is caused by the fact that you are repeatedly making the same motion. The muscles in your arms and shoulders are then constantly tensed whereas your body is hardly moving. These symptoms are known as **RSI** (*repetitive strain injury*). RSI often occurs in young people because they use smartphones, tablet, laptops, desktop PCs and game consoles a lot.

The first signs of RSI are a tingling feeling, fatigue and sensitivity in your neck, shoulders and arms. The symptoms disappear of their own accord if you rest for a while. If you feel these symptoms not just when you are making these motions but at other times too, you are one stage further. You will recognize this as pain and stiffness that suddenly appear. If you don't take action to stop it, you will eventually feel continuous pain.

To prevent RSI, it is important to move about regularly while using these devices. For example, you can walk around or loosen up your shoulders every twenty minutes. A good posture and changing your posture will also reduce the risk of pain.

fig. 3 Sitting still is not good for your body.



KNOWLEDGE

1

- a What is coordination?
- b What is motor memory?
- c Why is it that you don't have to think about how to do it every time you go swimming?
- d Which of these movements is not automatic for most people?
 - ☐ A cycling
 - ☐ B writing
 - ☐ C surfing
 - ☐ D tying your shoelaces

2

- a Jill played tennis at a high level for five years. Now she hasn't been playing sports for a year. Her coordination is *reduced* / *increased*. Her fitness level is *reduced* / *increased*.
- b Could she still play tennis? Explain your answer.

3

- a What is an injury?
- b When do you get muscle pains?
- c Explain why training more often reduces the risk of muscle pain.
- d What happens to muscles if you don't use them for a long time?

4

- a When do you get RSI?
- b If you have been texting for twenty minutes and you want to prevent RSI, your best option is to:
 - ☐ A put your phone down for five minutes and read a book or do your homework.
 - ☐ B spend five minutes gaming on your phone.
- c Explain your answer to Question (b).

5



Summary

Make a summary of this Basics section in the space provided, using a word web. Use the following terms: *injuries – motor memory – muscles – muscle pain – stronger – training*. Physical exercise leads to:

-
-
-
-
-
-

INSIGHT

6

- a Why do professional cyclists often have thin arms but thick upper legs?
- b Figure 4 shows the Dutch astronaut André Kuipers just after he has returned after weeks in space.
Explain why he is being carried.
- c When astronauts return to Earth, they need first to spend a while recovering and then start training again at a gentle pace.
Explain why both of these measures are needed.

fig. 4 The astronaut André Kuipers.



7

Your heart rate increases during a warm-up and especially during a match.

- a** Your heart gets stronger if you exercise, for example by going jogging.
Explain why.
- b** Kim wants to do some stretching exercises for her calf muscles before her tennis match.
Should she stand on her toes for these exercises or on the whole sole of her foot?
Explain your answer.

8

- a** Explain why using a phone, tablet, laptop, desktop PC and/or gaming console can lead to RSI.
- b** In the Middle Ages, books were not typed out or printed: they were copied by hand by monks. The monks sometimes suffered from ‘writer’s cramp’.
What would you call writer’s cramp now? Explain your answer.
- c** An injury to the elbow can sometimes mean that a violinist is unable to play for more than a year.
Is this typical violinists’ injury an example of RSI? Explain your answer.
- d** What can violinists do to reduce the risk of this injury?

+ 9

Muscles that you use unconsciously, such as the muscles in your stomach or intestines, have a different structure to your skeletal muscles. That is why organ muscles do not tire as easily as skeletal muscles.

- a** Explain why that is a good thing.
- b** You can’t train the small muscles in your skin that make your hairs stand on end.
Explain why not.
- c** Explain why it isn’t necessary either to train these arrector pili muscles.

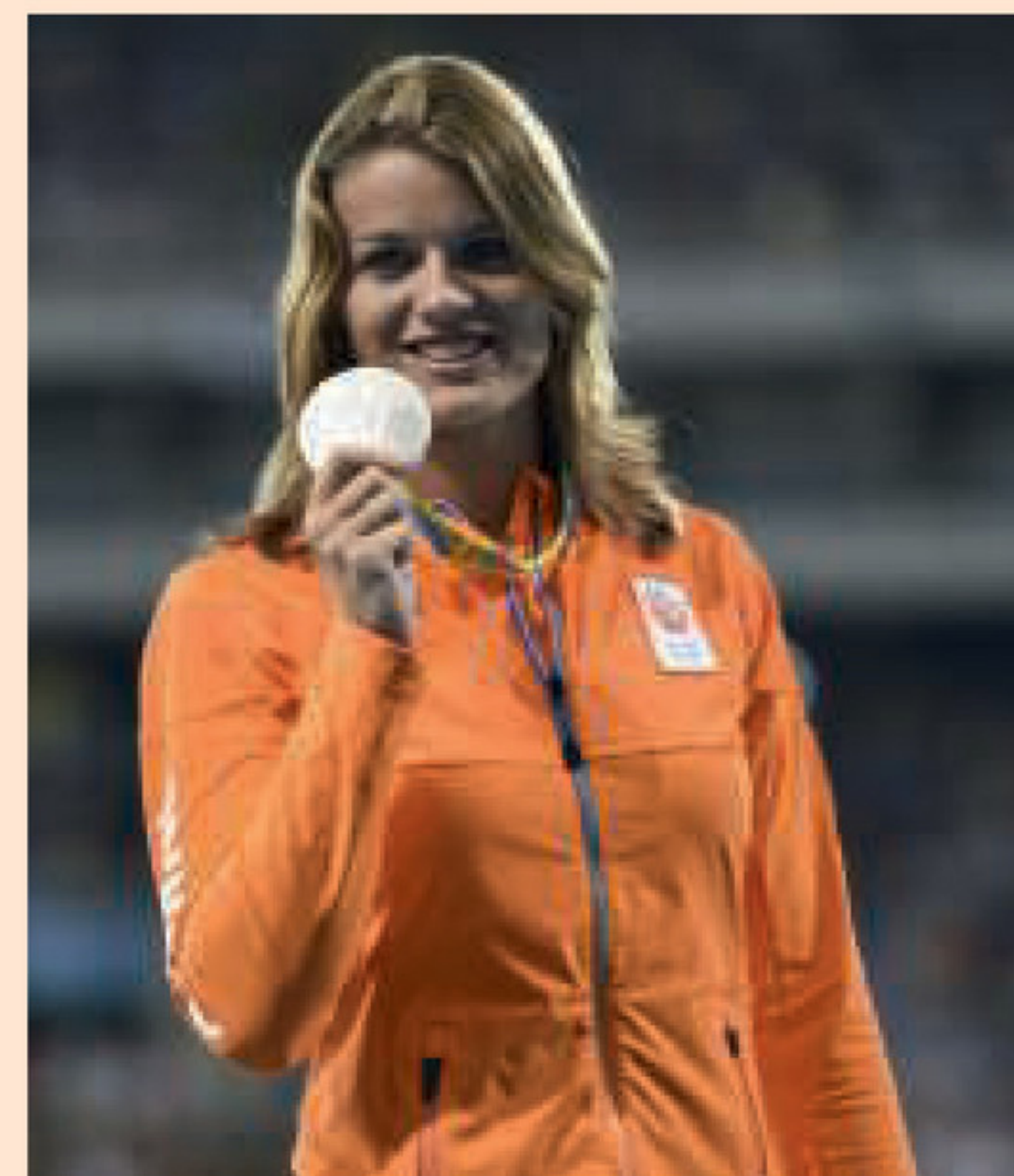
HOW IT FITS TOGETHER the living world

DAFNE SCHIPPERS

Dafne Schippers is the Netherlands' best female sprinter. In 2017, she became the world champion in the 200m. To achieve that, she had to train extremely hard on the track and with weights in the gym. She was not only exercising her muscles: she was also improving her coordination and of course her coordination.

Dafne trains not just so that she can run faster but also so that she can start more quickly. She has to get off the blocks and start sprinting the moment she hears the starting pistol. Her first few strides are short but powerful with the knees coming up high. Her torso stays low. Gradually her strides get longer and her torso becomes more upright. After about 30 m, her torso is fully upright and her stride length is at its maximum. After years of training, she doesn't have to think about this anymore.

fig. 5 Dafne Schippers won silver at the Olympic Games.



10

Read the text about 'Dafne Schippers'.

Dafne trains with weights in the gym. She does squats with heavy barbell weights on her neck.

- a** Explain what effect this has on her leg muscles.
- b** Which muscles that are also important for sprinting can't Dafne train?
- c** Dafne always starts her training session with *a cool-down / a warm-up / stretching exercises* followed by *a cool-down / a warm-up / stretching exercises* and she ends with *a cool-down / a warm-up / stretching exercises*.
- d** Explain why you need good coordination for the start of the sprint.
- e** Explain why Dafne's start is an automatic movement.

 Go to the *Flash cards* and the *Test yourself* section.

How it fits together

A BIRD-BRAINED APRIL FOOL

On 1 April 2018, unsuspecting British viewers watching the TV channel BBC1 saw a surprising film clip. A presenter in a red thermal jacket announced that something strange had happened in a colony of penguins.

The clip was part of the BBC series *Miracles of Evolution* and had been recorded on the snow-covered island of King George, near the South Pole. The presenter said that researchers had been filming the behaviour of Adélie penguins when the weather worsened. The researchers expected that the penguins would huddle up closer to one another but the penguins actually did something very different. They started to jump and flap their wings. A little later, a whole flock of penguins was flying through the air away from the cold, towards the warm tropics. At the end of the clip, viewers saw the penguins landing among the toucans in the Amazon rainforest.

A lot of people believed the film about flying penguins. But if they had looked more closely at the name of the person who made the clip, Prof. Alid Loyas, they would have realized they were being fooled. ‘Prof. Alid Loyas’ has the same letters as ‘April Fools’ Day’!

fig. 1 Adélie penguin.



VERSATILE WINGS

So there were no flying penguins, sadly. But penguins still make good use of their wings. Rather than using them to fly, they use them to swim very fast through water, at up to 40 km per hour. They move their wings when swimming just like birds that fly. Even on land, the penguins use their wings. When they quarrel, they can hit one another hard with their wings, up to eight times a second. Their wings play an important role when they walk too. Penguins walk on their heels, which gives them their characteristic waddle. They spread their wings to keep their balance. Finally, they use their wings if they can't go fast enough by walking upright. Penguins then lie on their stomachs and push themselves along with their feet and wings – like sledging along the snow. That's something other birds can't do.

EXERCISES

1

Figure 2 shows the skeleton of a penguin. A penguin largely has the same bones as a human.

a Write down the names of the numbered bones. Use the words: *femur* – *neck vertebra* – *fibula* – *metacarpal* – *metatarsal* – *lower jaw* – *humerus* – *ribs* – *skull* – *tibia* – *shoulder blade* – *radius* – *tail vertebra* – *phalanx*. Four bones have already been labelled.

b Where is the penguin's knee?

Draw a cross in the correct place in figures 1 and 2.

c Is a penguin's tail part of its torso or is it a limb? Explain your answer.

d Penguins can jump over obstacles with both feet at the same time.

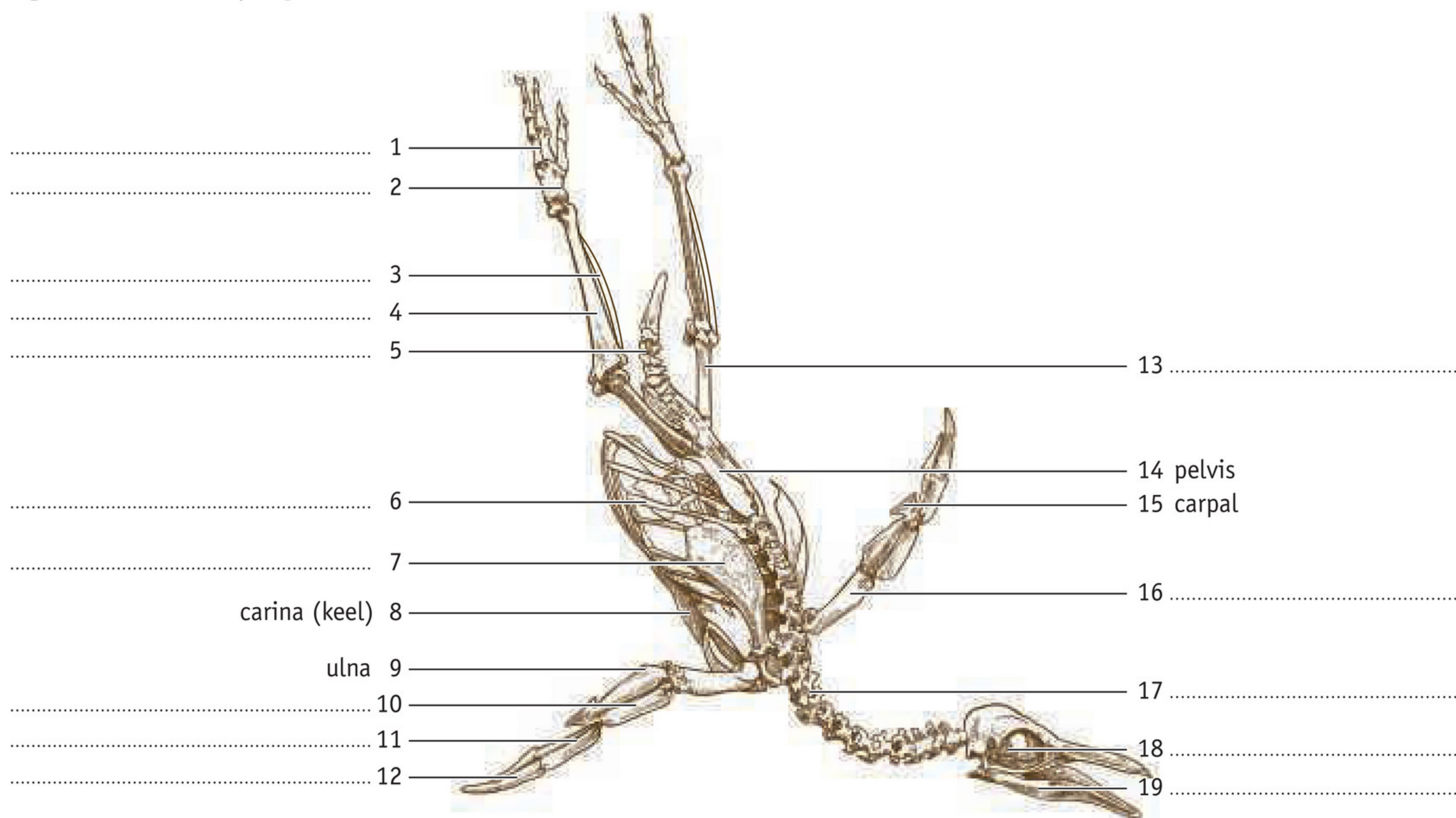
In figure 2, draw in a calf muscle in the penguin skeleton.

e The calf muscle has an antagonist.

What might this muscle be called?

- ☐ A short big toe flexor
- ☐ B femoral biceps
- ☐ C foot sole muscle
- ☐ D anterior tibial muscle

fig. 2 Skeleton of a penguin.



2

- a** A penguin walks on *the soles of its feet / its toes / the tips of its toes*.
- b** A penguin basically walks 'in a squatting position'.
If you walk in a squatting position, your knee joints are *higher / lower* than your hip joints.
- c** Try to walk in a squatting position yourself.
Which muscles start hurting first?

.....

.....

.....

.....

- d** Look at the muscles you wrote down in Question (c).
What will these muscles be like in the Adélie penguin?

3

Penguins have a large, flat piece of bone sticking out from the breastbone and called the carina or keel (see figure 2). The keel is an attachment site for pectoral muscles. Penguins' pectoral muscles are thick muscles.

- a** Why are a penguin's pectoral muscles thick?
- b** Penguins can't fly but they do have a sternal keel. Ostriches (flightless birds) don't have a keel.
Why doesn't the ostrich need a keel?
- c** Penguins can only move their wings from the shoulder. The elbow and wrist have almost fused.
Do you think penguins have pivot joints in their wings? Explain your answer.
- d** What type of bone connection lets penguins spread their wings to keep their balance?
 - ☐ A a ball-and-socket joint
 - ☐ B a suture
 - ☐ C a hinge joint
 - ☐ D cartilage
 - ☐ E fused bones

4

- a** Roughly how many neck vertebrae do penguins have?
- b** Humans can't bend their necks as far as penguins can.
Explain why not.
- c** Do you think a penguin's spinal column also forms a double S-shape? Explain your answer.
- d** Some organs of the Adélie penguin are protected by a layer of abdominal fat rather than by the ribcage. These organs need protection in particular when the penguin is 'sledging'.
Write down four organs that are protected by a layer of abdominal fat in penguins.

5

Penguin chicks develop water-resistant feathers after two months, at which point they start swimming.

- a** Is swimming already an automatic movement for the chicks? Explain your answer.
- b** Are all wing movements in adult penguins automatic movements?

7

Bone shapes and functions

LEARNING OBJECTIVE

4.7.14 You can describe the relationship between the shape and function of bones.

► Practical activity 8

TAXONOMY	LEARNING OBJECTIVE AND EXERCISES
	4.7.14
Remembering	
Understanding	
Using	1, 2bcd, 3, 4a, 5, 6
Analysing	2ae, 4b

The shape of a bone is related to its function. Animals have various adaptations in their bones.

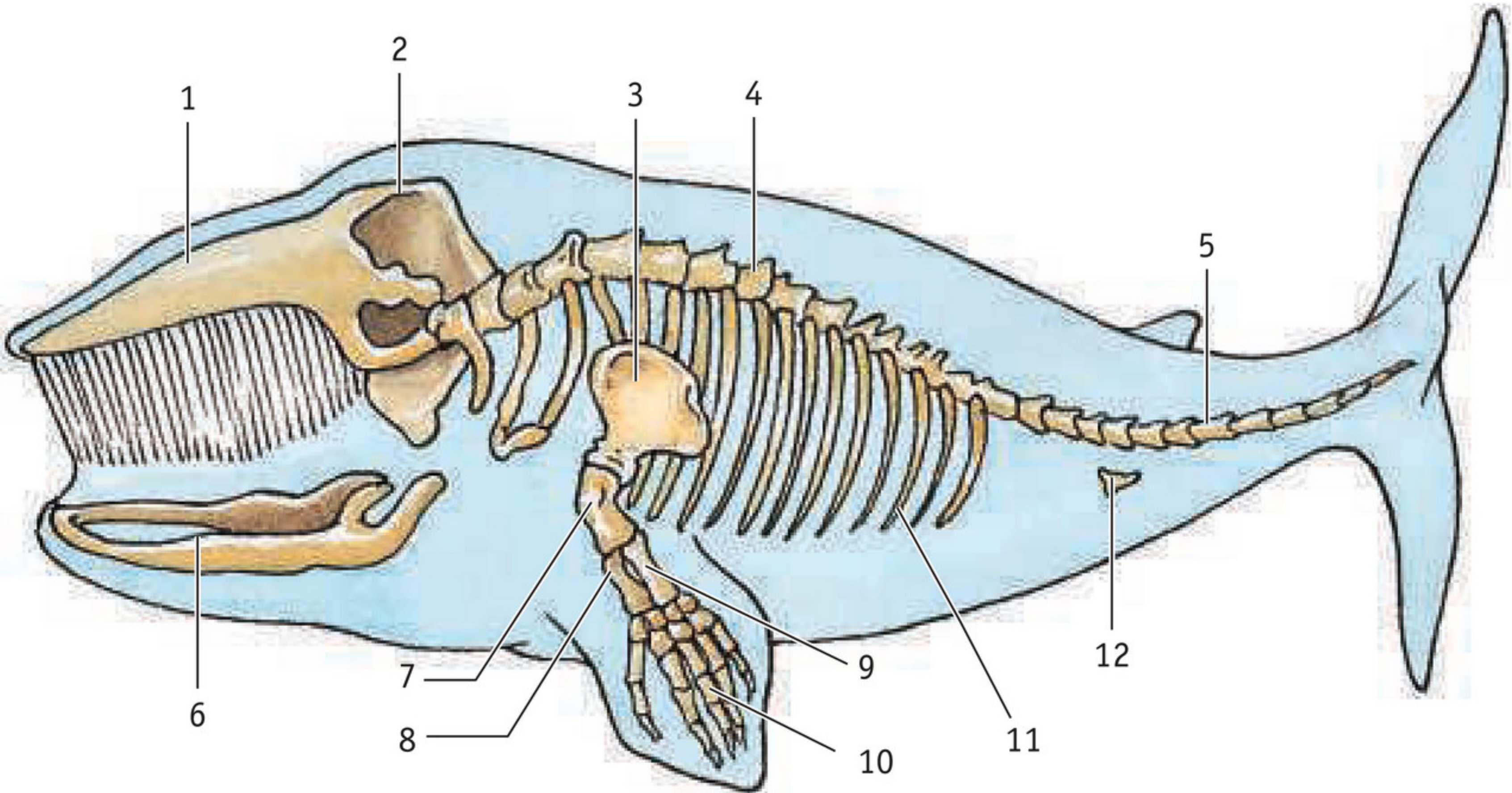
MAMMALS

There are a lot of similarities between animals in the structure of their skeletons, but there are also differences. The differences are related to differences in the way they live. A dolphin, for instance, has a streamlined body (see figure 1). That lets it move more quickly through the water. Other animals have other adaptations in their skeletons. Figure 2 shows the skeletons of three mammals.

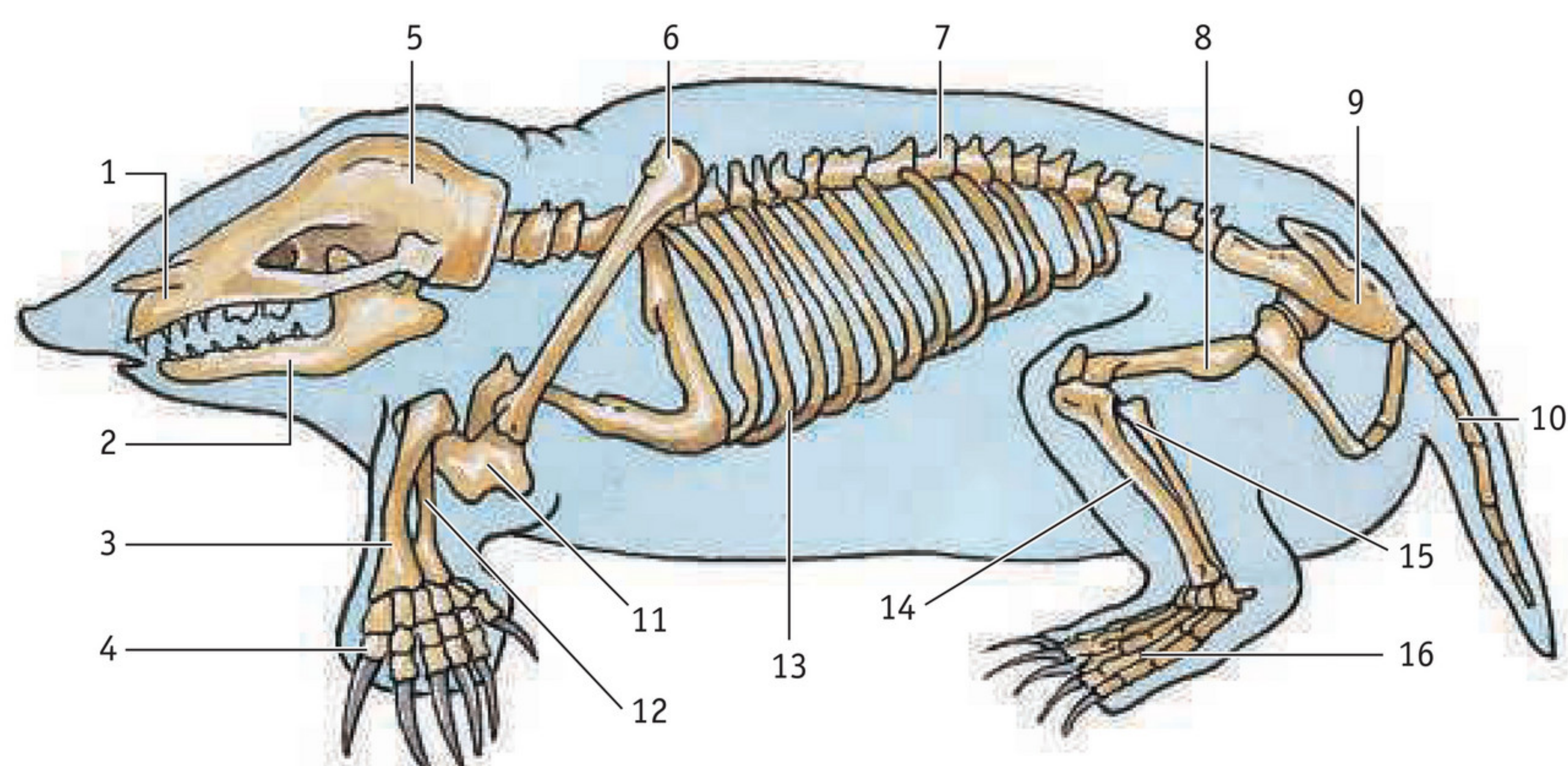
fig. 1 A streamlined body.



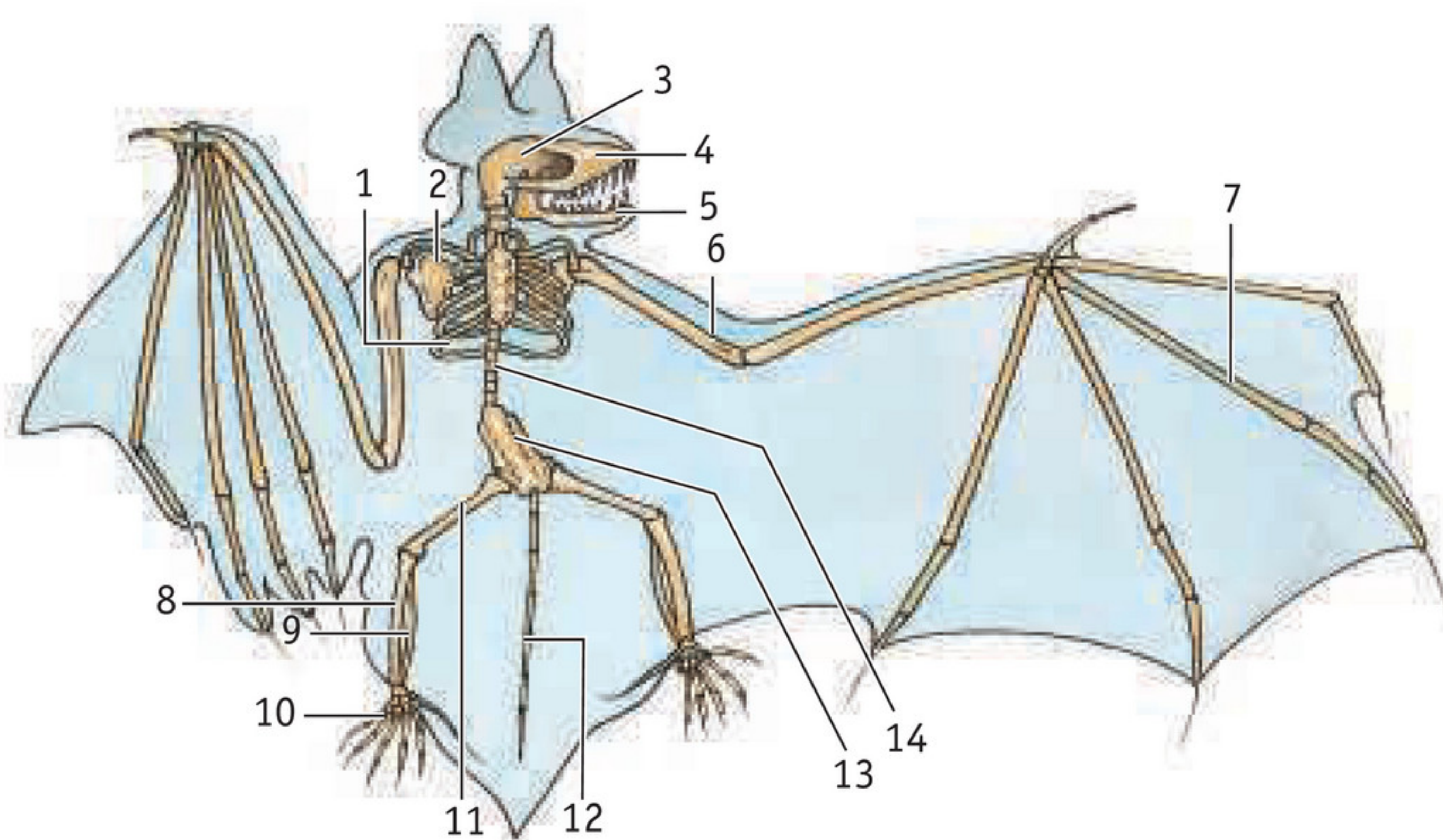
fig. 2



1 whale



2 mole

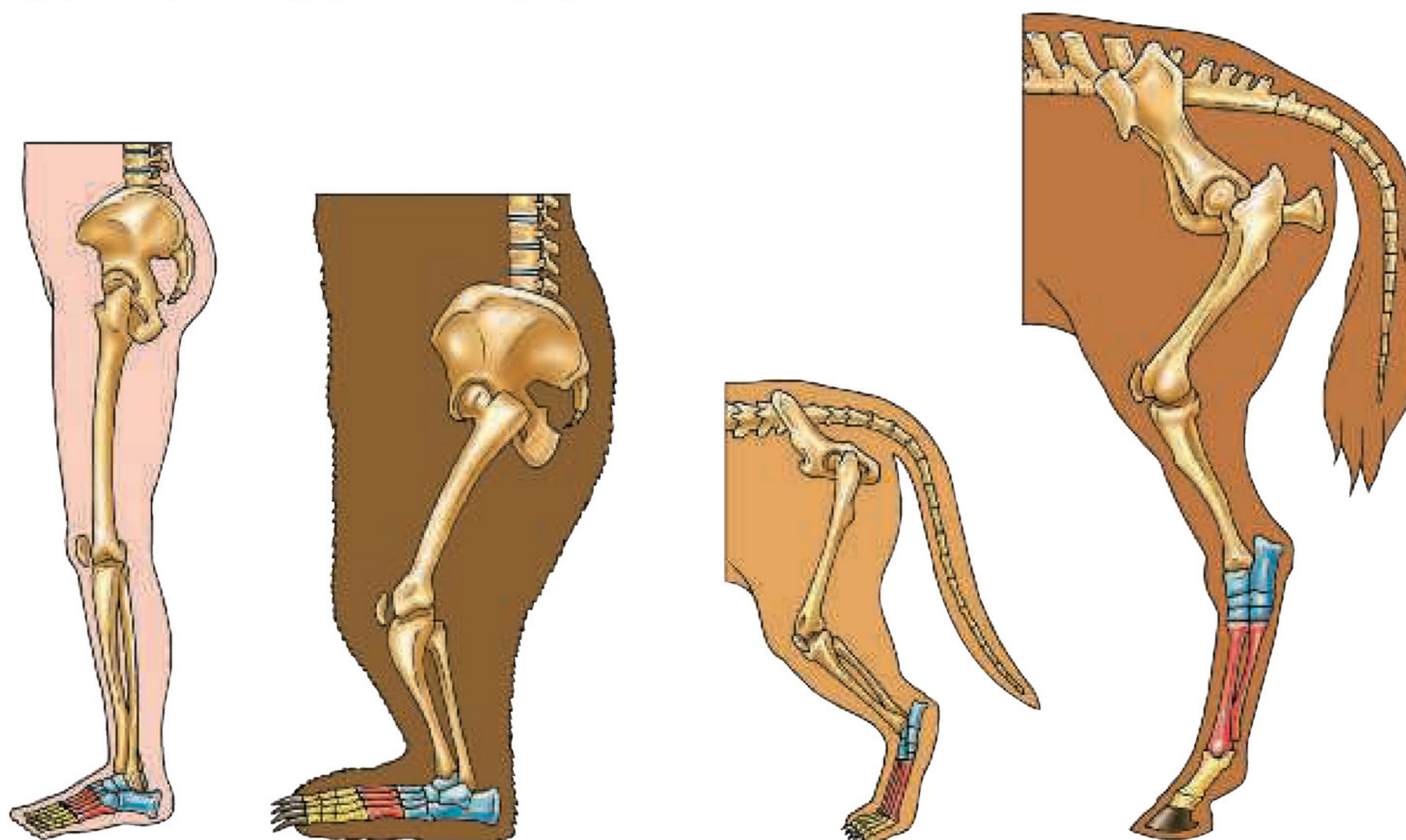


3 bat

LEGS AND FEET

In mammals, the shape of the legs depends on the way that an animal lives. Figure 3 shows the hind legs of a human, a bear, a cat and a horse. Humans and bears walk on the soles of their feet (they are plantigrades), cats walk on their toes (digitigrades) and horses walk on their hooves (unguligrades).

fig. 3 Plantigrades, digitigrades and unguligrades.



Many structures we build are arched. Figure 4 shows an arched railway bridge, for example. The same shape also appears in the human foot (see figure 5). The sole of your foot is **arched**. This shape makes your feet more able to support weight.

fig. 4 Arches.



fig. 5 Arched.



EXERCISES

1

Complete the table. Fill in the numbers used in figure 2 to label the bones. There is not necessarily a number in every box for every animal. The numbers of some bones have already been filled in.

	Whale	Mole	Bat
Bones of the hand			
Bones of the foot	–		
Upper jaw			
Thighbone	–		
Ulna		12	–
Pelvis			
fibula	–	15	
Lower jaw			
Humerus			
Ribs			
Skull			
Tibia	–		8
Shoulder blade			
Radius	8		–
Caudal (tail) vertebrae			
Spinal column			

2

- Use figure 2 for this exercise.
- a What bone do whales have that has no function? Why is this not needed in whales?
 - b What shape is a mole’s shoulder blade?
 - c What shape is a mole’s humerus?

- d What does a mole use its forelegs for?
- e The shape of a bone is related to the function of the part of the body where that bone is located.
How do you see this in the forelegs of a mole and the forelegs of a bat?

3

What benefit do unguligrades get from the fact that they walk on the tips of their toes?

4

Look at the cheetah in figure 6.

- a How would you class a cheetah? *digitigrade* / *unguligrade* / *plantigrade*
- b You can see how a cheetah runs.
What benefit does this style of running have for the cheetah? Use the information from the text 'The stride length makes the difference' (see figure 7) in your answer too.

fig. 6 A cheetah running.



fig. 7

The stride length makes the difference

The difference in stride length between a top athlete and a recreational runner is huge. A top distance runner runs the marathon (a distance of over 42 kilometres) in about 28,000 strides. The number of strides can be almost double that, namely 53,000 strides, for recreational runners. Extending the stride length without it having to cost more energy therefore results in faster times.

5

You need a plastic ruler for this exercise (see figure 8).

- Get someone to hold the plastic ruler firmly at both ends. Press down on it at the centre (see figure 8).
 - Do the same thing again, but now with the ruler bowed upwards.
- In which case is it easiest to bend the ruler downwards?

fig. 8



1



2

6

- a Why is it useful for feet to be arched?
- b List a few examples from daily life that make use of an arched (bowed) shape for strength.

 Go to the *Flash cards*.

8 Injuries

LEARNING OBJECTIVE

4.8.15 You can name the causes and consequences of some injuries.

TAXONOMY	LEARNING OBJECTIVE AND EXERCISES
	4.8.15
Remembering	
Understanding	3, 4a, 5
Using	1b, 4ce
Analysing	1ac, 2, 4bd

When you play sports, sometimes something goes wrong. You can get muscle aches or injuries. In that case, it is good if you know what to do.

MUSCLE STRAIN

You often get muscle aches if you play a sport you are not used to. The muscle ache usually soon goes. The muscle has not been damaged. Overdoing the effort or training, or a sudden movement, can cause a **muscle strain** or even a tear. In that case the muscle is damaged. You might for example ‘pull’ your calf muscle. A pulled muscle generally recovers if it gets rest. In severe cases, a pressure bandage is used.

FRACTURES

As well as muscles, you can also get injuries to bones, joints and tendons. Racing cyclists often get **fractures** if they have a fall, particularly fractures of the collarbone. In footballers, fractures of the tibia and fibula are common, usually due to hard tackling. If you fracture a bone, you have to go to hospital. Bone fractures are easy to see on X-ray photos (see figure 1).

fig. 1 Fractures from sports.

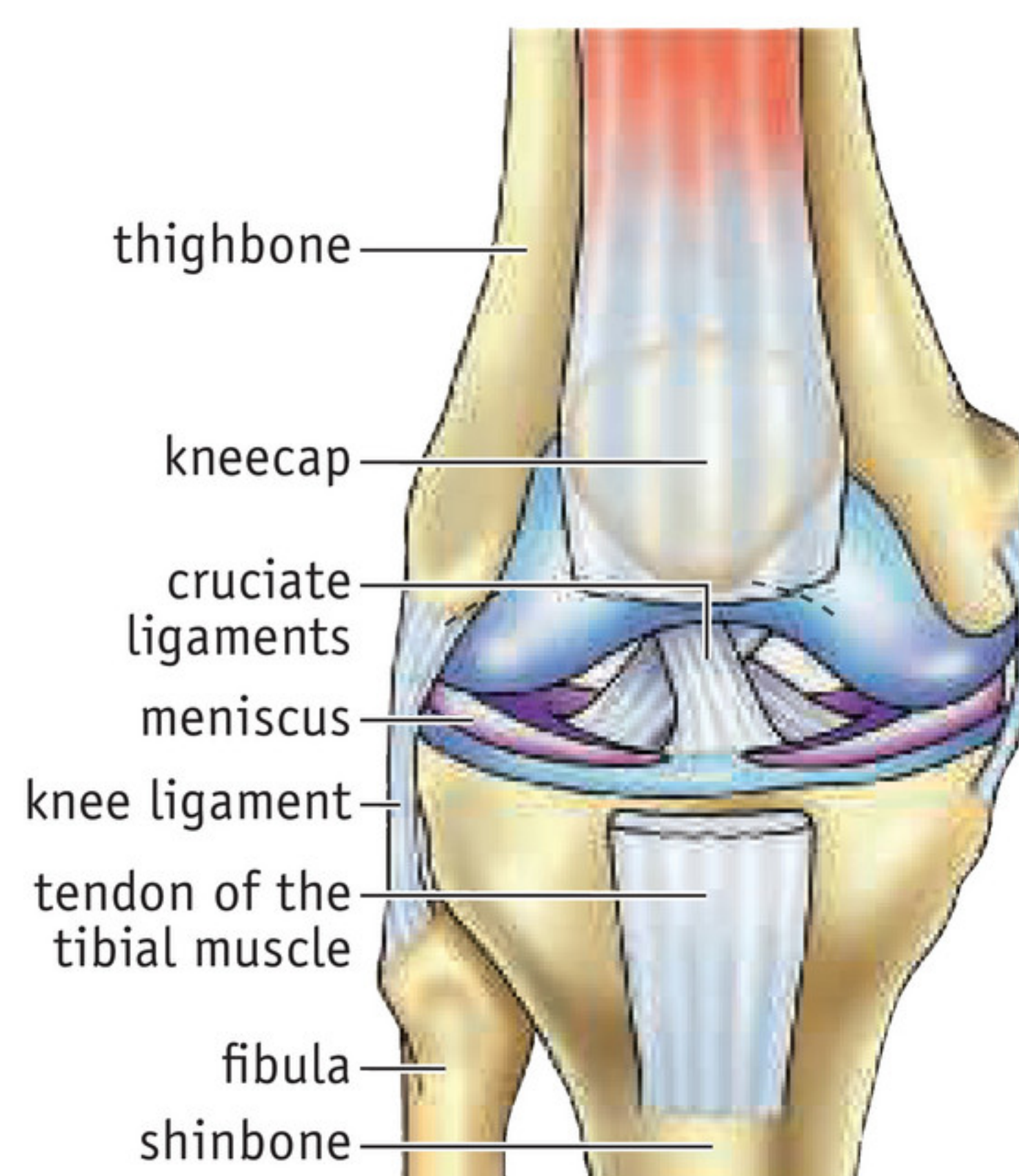


For the bone to heal properly, the two halves must be aligned correctly as they grow back together. A doctor puts the broken bone back in the correct position. This is called **setting** the bone. The two halves of the bone are generally held in place with a plaster cast. If that does not work, screws and plates or pins may be used to immobilize the bone (see figure 2). Once the two halves of the bone have grown together again, the plaster cast can be removed.

fig. 2 Fracture mended with screws and a plate.



fig. 3 The knee joint.



RUNNER'S KNEE

A runner's knee is one of the most common injuries. The knee joint has two discs of cartilage between the thighbone and the tibia. A disc of cartilage like this in the knee is called a meniscus (see figure 3). If the body turns around while the lower leg stays in place, a meniscus can tear. This is very painful. There is then usually also damage to the joint capsule and the ligaments (the knee ligaments or the cruciate ligaments). Accumulation of fluid in or around the knee causes swelling. It is also possible for a piece of the meniscus that has come loose to prevent the knee from straightening. We say that the knee is 'locked'.

Sometimes rest is enough to let the knee joint heal, but a torn meniscus often needs to be treated surgically.

CONTUSION

A **bruise** or **contusion** is damage to tissue without anything being torn or broken. Contusions (bruises) generally occur when you fall or get a knock, blow or kick. That often causes internal bleeding, which you see as a black and blue area on your skin. You can also get swelling with a bruise because fluid accumulates. Cooling helps when you have a swelling. For example, you can place ice in a tea towel or an ice pack on the swelling (see figure 4) or hold the swollen area under cold water. You can also get special sprays to cool the swollen area down. The cold reduces the pain and the swelling. After that, rest will heal the injury.

fig. 4 Cooling a swelling.



fig. 5 A contusion due to a sprain.



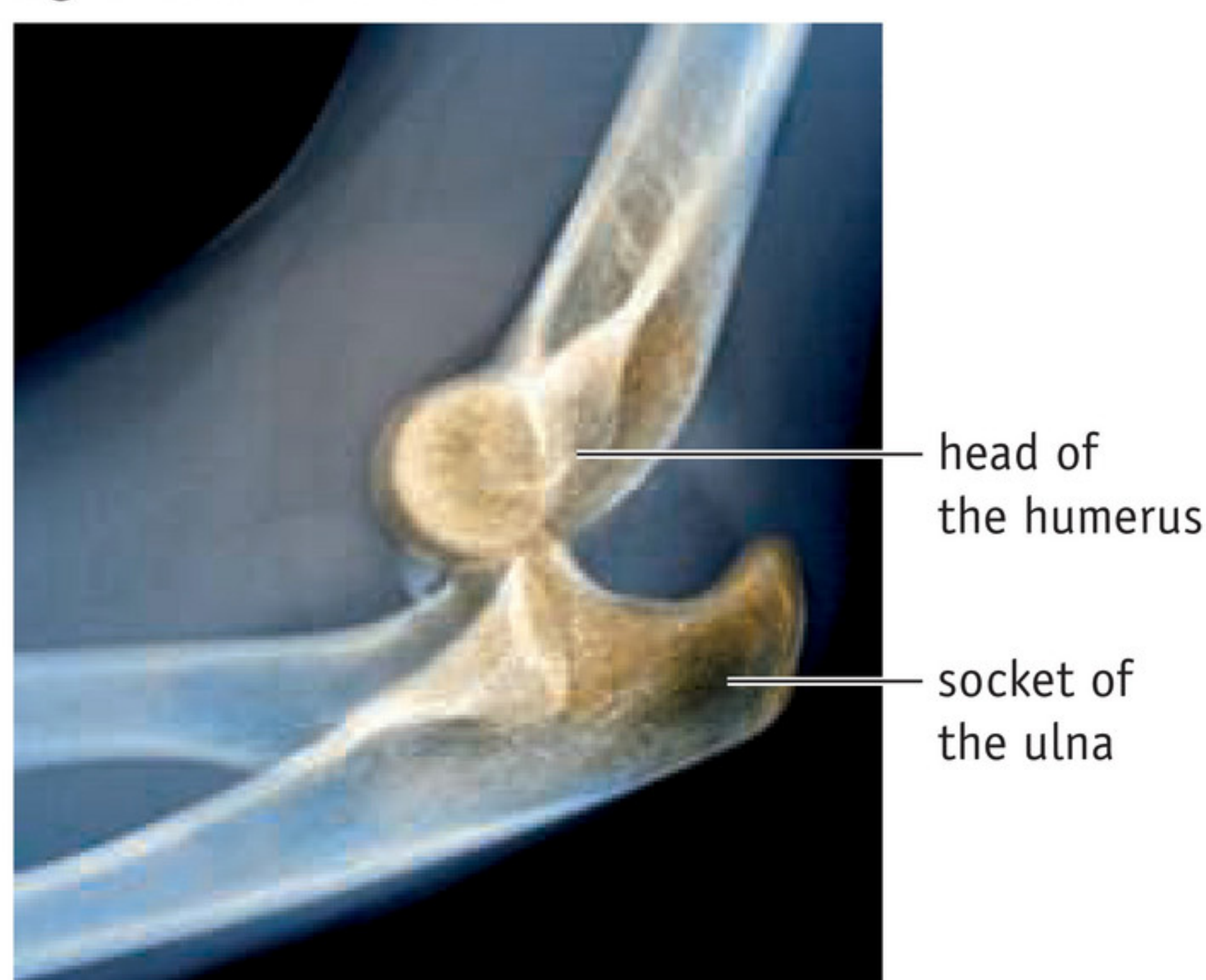
SPRAIN

A **sprain** is a bruise to a joint. If you sprain your ankle, for example, the joint capsule and the ligaments in your ankle can get overstretched. That can make a bruise appear (see figure 5). If the sprain is severe, the joint capsule and the ligaments may even tear. You have then torn your ankle ligaments.

DISLOCATION

In a **dislocation**, the ball of the joint has come out of its socket (see figure 6). Dislocations can occur for instance if you fall wrongly on your arm. Your elbow can come out of the socket. A doctor then has to put the ball end of the humerus back in place in the socket of the ulna.

fig. 6 Dislocated elbow.



CAUSES OF SPORTS INJURIES

All kinds of factors can cause sports injuries. Important causes are:

- rough play and breaking the rules (unsporting behaviour)
- not being properly trained and/or not having sufficiently good technique
- lack of fitness
- overuse of muscles and fatigue
- not doing enough warming up, stretching exercises and/or cooling down
- bad weather conditions (rain, cold, ice, heatwave)
- starting sports again too soon after an injury
- poor sports kit (e.g. old equipment or wrong footwear)

EXERCISES

1

- a When a racing cyclist has a fall, their upper body is often the first part to hit the ground. The cyclist tries automatically to break the fall with their arms. This exerts large forces on the pectoral girdle. The collarbone can be broken in this type of fall. The shoulder blade does not usually break.
Why do you think the shoulder blade doesn't break?
- b Which part of the knee is damaged in a runner's knee?
- c In the past, a damaged meniscus was often removed surgically. This sometimes gave problems in later life. The knee that the meniscus had been removed from could become very painful.
What consequence does removing the meniscus have for the cartilage in the knee joint?

2

In cramp, a muscle suddenly contracts powerfully and then remains tensed. This can be so forceful that muscle fibres tear. Moving the foot can reduce cramp in the calf.

Figure 7 shows somebody with cramp in the calf muscle.

To stretch the calf muscle, the foot should be pushed in the direction of *arrow 1* / *arrow 2*.

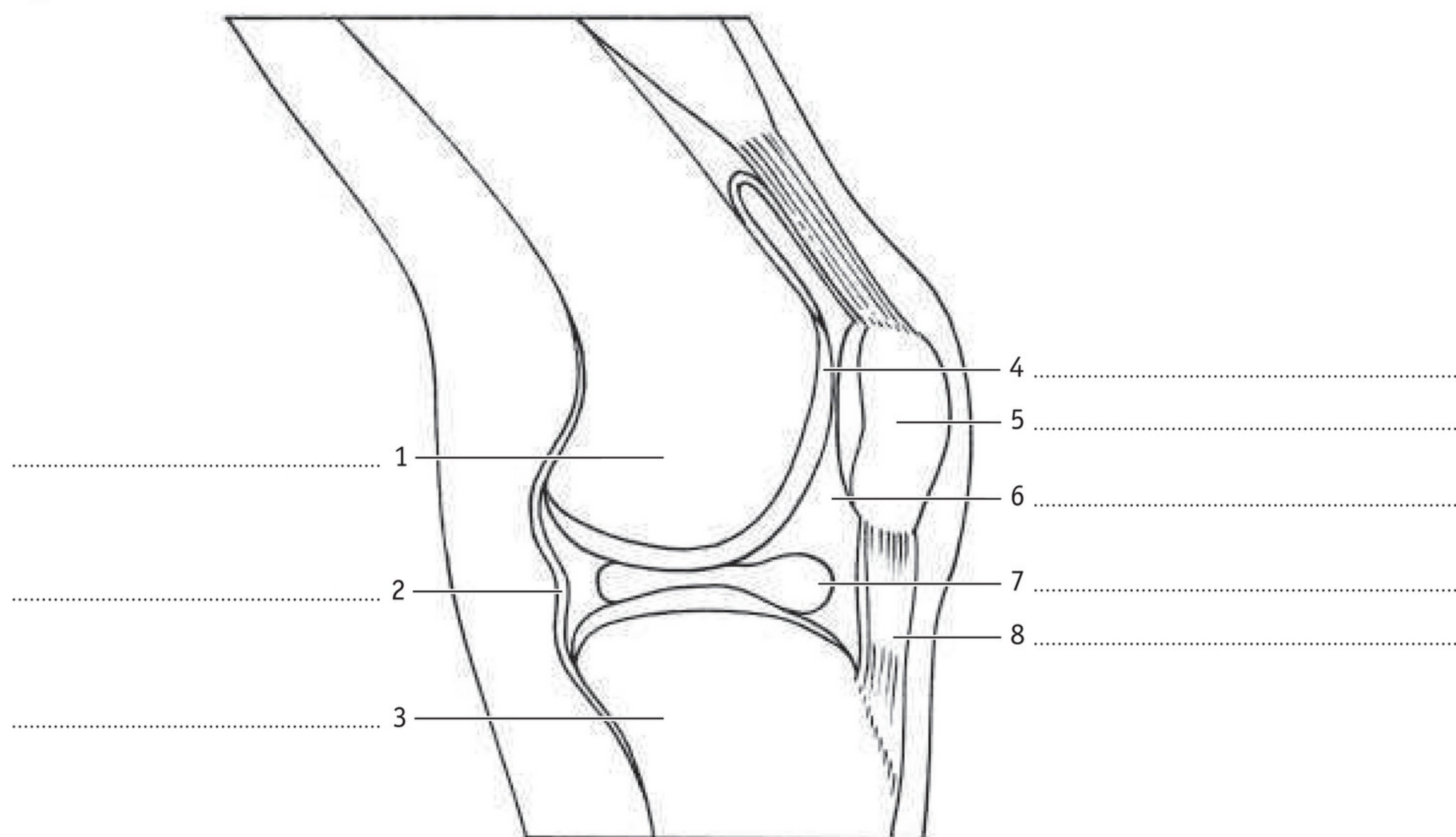
fig. 7 Cramp in the calf muscle.



3

Write down the names next to the numbered parts in figure 8.

fig. 8



4

Read the text 'Injury to the talus' in figure 9.

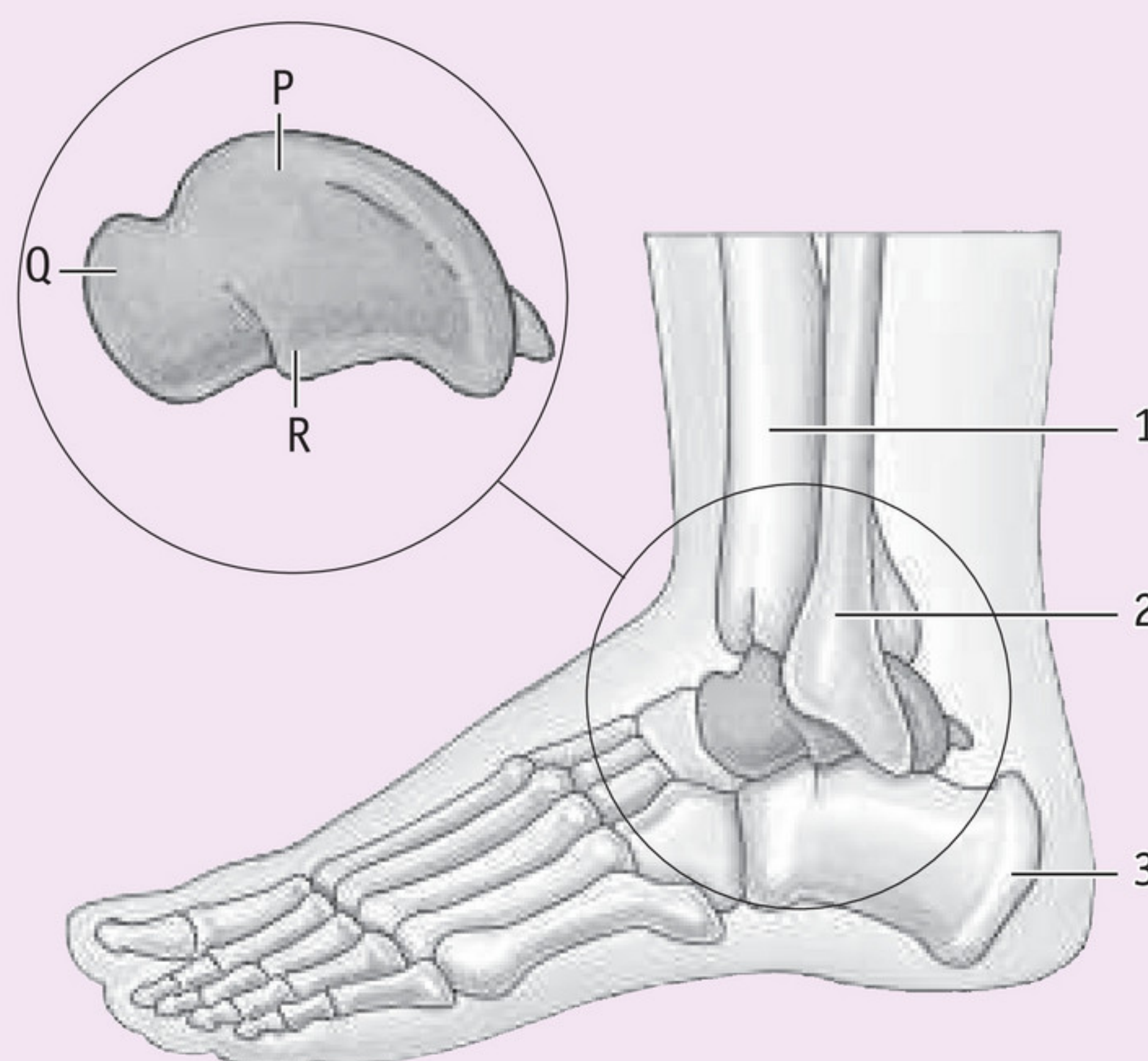
The top bone in the foot is called the talus or ankle bone. Particularly in sports that involve a lot of jumping and running, such as football, there is a risk of damage to the talus.

- a The injury to the ankle joint is a consequence of wear and tear in the cartilage that covers the talus.
The talus belongs with the *metatarsals* / *phalanges* / *tarsals*.
- b In which place or places is there cartilage on the talus: P, Q and/or R (see figure 9)? Explain your answer.
- c In which other injury is there also a risk of damage to the cartilage of the talus?
- d To get at the talus during an operation, parts of the ankle joint have to be cut through. Which parts are they?
- e Which bone in the figure is labelled number 2?
 - ☐ A femur
 - ☐ B heel bone
 - ☐ C fibula
 - ☐ D tibia

fig. 9

Injury to the talus

During running and jumping, the weight of the body comes down on the talus. There is cartilage at the points where this ankle bone is connected to other bones. Overuse can result in this cartilage becoming worn. Wear on the cartilage at the talus often causes severe pain. Doctors can try to stimulate growth of the cartilage by shaving the surfaces of the bone. Recovery after such an operation takes months and the quality of the newly formed cartilage is not always good enough.



5

Which injury belongs with each description?

- | | | |
|--|-----------------------|---------------------------------------|
| A damage to a muscle caused by a sudden movement | ☐ | ☐ 1 contusion |
| B damage to tissue without anything being torn or broken | ☐ | ☐ 2 dislocation |
| C the ball-shaped bone has come out of the socket | ☐ | ☐ 3 muscle strain |
| D overextension of the joint capsule and ligament, but the bones of the joint remain in position | ☐ | ☐ 4 sprain |

 Go to the *Flash cards*.

Learning how to do research

1

MEASURING ACCURATELY

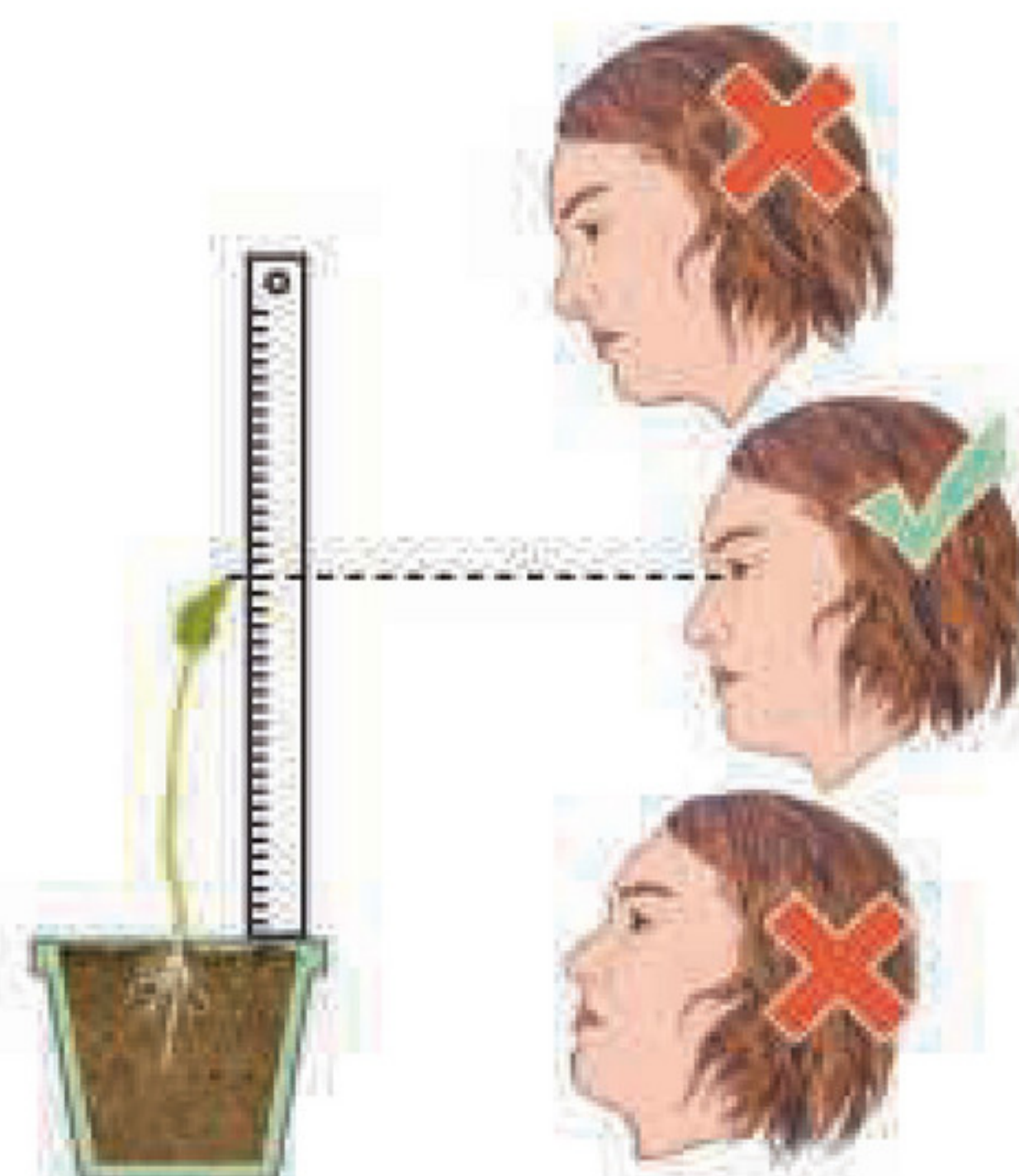
► Basics 4 | ► Learning objective 4.O.16 | ► Practical activities 3, 5 and 6

In research, you collect data by making measurements. Research can go wrong if there are measurement errors. You can avoid measurement errors by carrying out the measurements accurately and in the same way every time. For example, you need to measure the length of a plant's stalk (see figure 1). You then need to measure from the same point every time, for example the edge of the pot. You must also look at the ruler horizontally every time (not diagonally downwards or diagonally upwards).

If you are measuring something with a digital device, write down the result to one or more decimal places.

Write down your measurements in the same units every time. So you measure the length of the stalk in centimetres every time (not in centimetres one time and in millimetres the next). This lets you calculate the average easily later on.

fig. 1



EXERCISE

1

Mia is researching whether her classmates with longer legs can run faster than her classmates with shorter legs. She divides the class into two groups: one group with long legs and one group with short legs. Each classmate sprints 100 m. Mia measures each time with a stopwatch and then calls it out to Lily, who writes the time down.

Mia calls out, "Aidan's time was $16\frac{17}{100}$ seconds."

a Which way of writing it down is most accurate?

- ☐ A 16.1 s
- ☐ B 16.17 s
- ☐ C 0.27 min
- ☐ D 0.2666 min

b Jade researches the same question but she lets her classmates run once round the sports field. Dennis runs round in 1 minute 30.04 seconds.

Why is it not a good idea to write down the time in the number of minutes and seconds?

c What is the best format for Jade to use when writing down Dennis' time?

2

RESULTS IN TABLES AND GRAPHS

► Basics 4 | ► Learning objectives 4.O.17 and 4.O.18 | ► Practical activities 3, 5, 6 and 7

TABLES

A table lets you write down results in a clear way. If you don't have many results, you can already draw a conclusion from the table to answer your research question (see table 1). The question you are studying is: "Is your heart rate faster when you are sitting or when you are standing?" The table gives the average heart rates of five students. The average heart rate when sitting is 69 bpm (beats per minute) and the average when standing is 80. Conclusion: your heart rate is faster when standing.

Table 1 Heart rates when sitting and standing.

Pupil	Sitting (bpm)	Standing (bpm)
1	69	83
2	69	79
3	72	83
4	70	79
5	65	76
average	69	80

GRAPHS

If you have a lot of results or if you measure a lot of factors, you can't always draw a conclusion straight away – see table 2. This table is similar to table 1 but it contains more data. There are more students, the sex of the students has been recorded and the heart rate while walking has also been measured.

Table 2 Heart rates when sitting, standing and walking.

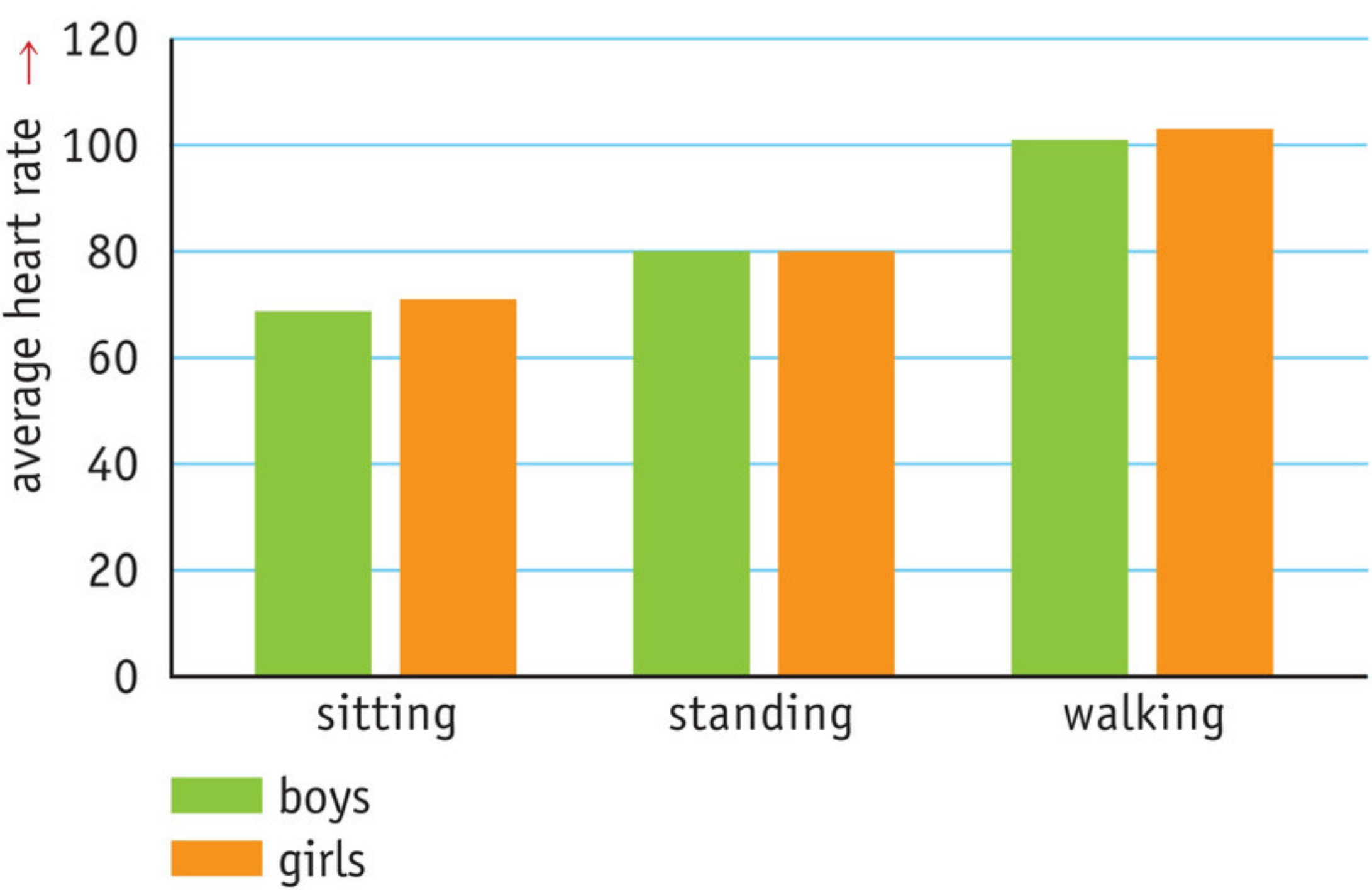
Pupil	Sex	Sitting (bpm)	Standing (bpm)	Walking (bpm)
1	boy	69	79	98
2	boy	72	83	104
3	boy	65	76	99
4	boy	67	82	103
5	boy	72	85	101
6	girl	69	83	103
7	girl	70	79	102
8	girl	74	83	106
9	girl	73	80	105
10	girl	69	80	99
average for boys		69	81	101
average for girls		71	81	103
average for boys and girls		70	81	102

You can give a clear picture of the results in table 2 using a graph. The type of graph you choose depends on your results and the aim of your research.

BAR CHART

A **bar chart** lets you compare the averages of different groups. You put the groups on the x-axis and the average measurement per group on the y-axis. Figure 2 gives the results of table 2 as a bar chart.

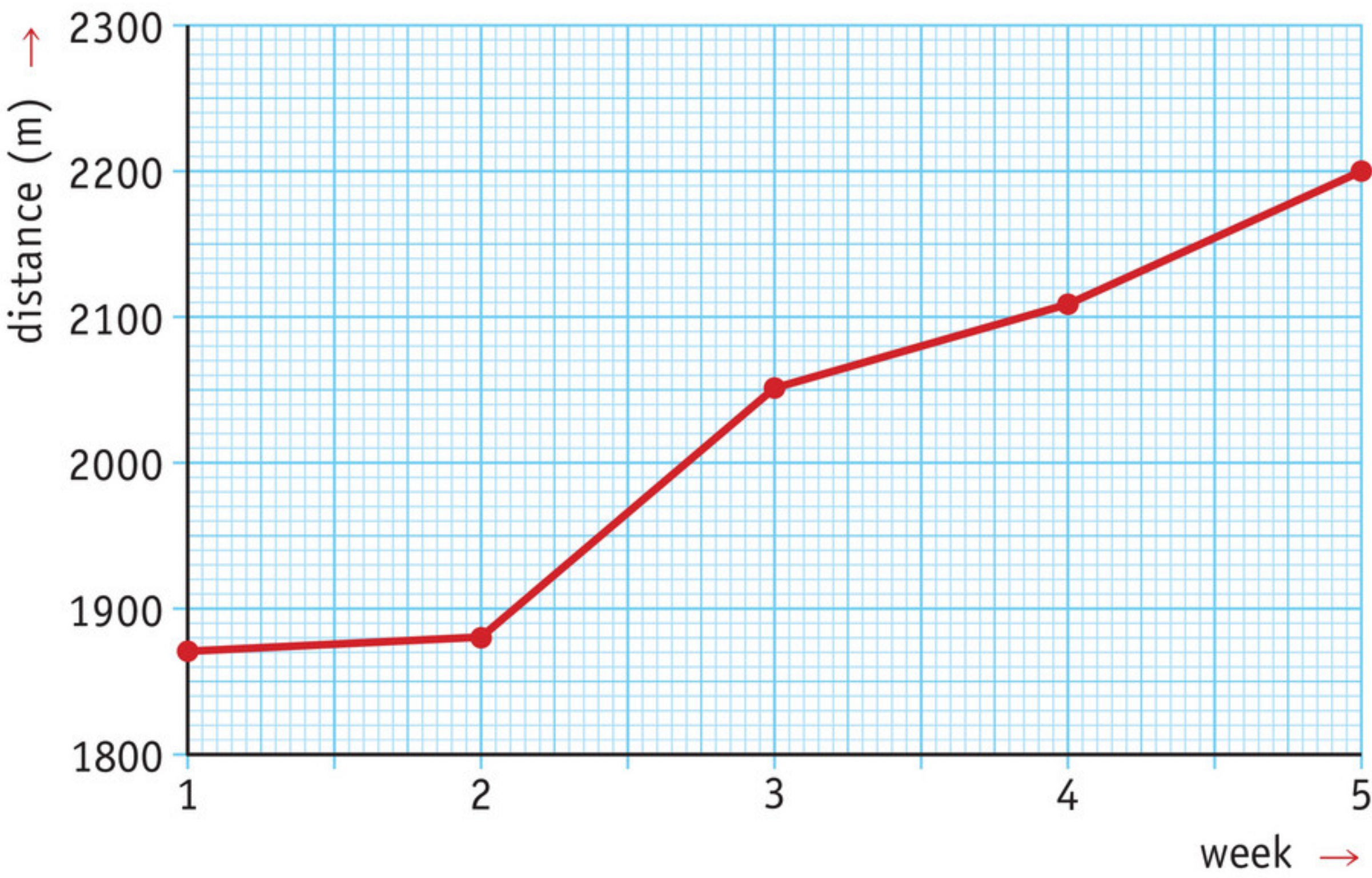
fig. 2 Bar chart.



LINE GRAPH

You use a **line graph** to show the change over a time interval or over a certain distance (see figure 3). You put the time or distance on the x-axis. You put the measurement you got for each time or distance on the y-axis. For example, you recorded how many metres you can walk in twelve minutes as training for the Cooper test every week for five weeks. You put the number of weeks since the start on the x-axis. You put the distance you walked that week on the y-axis.

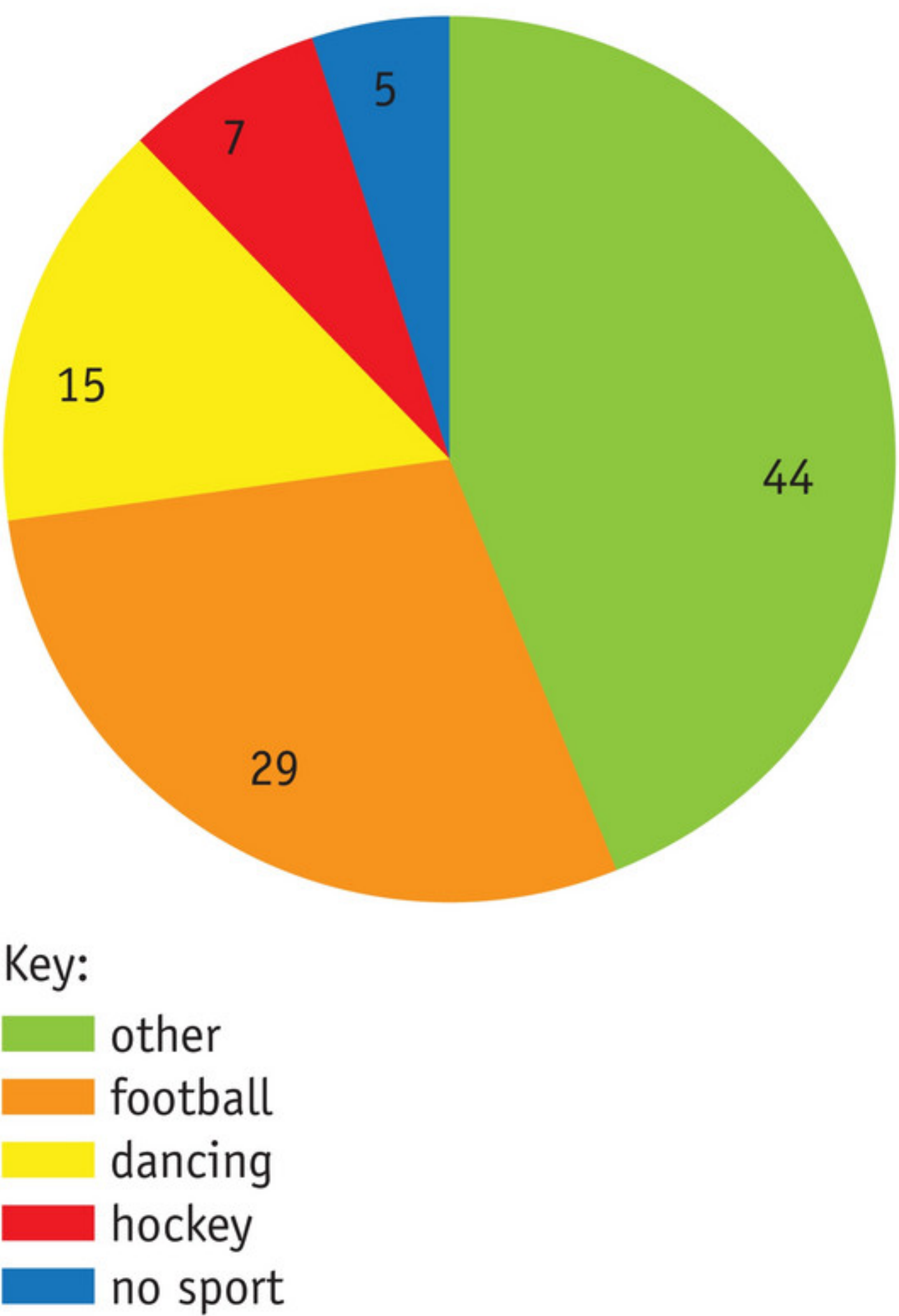
fig. 3 Line graph.



PIE CHART

A **pie chart** lets you compare the sizes of different groups. You can see what share each group has and how big each group is. You usually show the percentages in the pie chart. If one or more groups are very small, you can show the percentages in the legend. Figure 4 shows a pie chart of the sports the students in a first-year class play.

fig. 4 Pie chart.



EXERCISES

1

- Read the text about ‘Graphs’ in figure 5.
- a Which graph would be best for the teacher to use?
 - A bar chart
 - B line graph
 - C pie chart
 - b Which graph would be best for Sophie and Joe to use?
 - A bar chart
 - B line graph
 - C pie chart
 - c Which graph would be best for Fred to use in his presentation?
 - A bar chart
 - B line graph
 - C pie chart

fig. 5

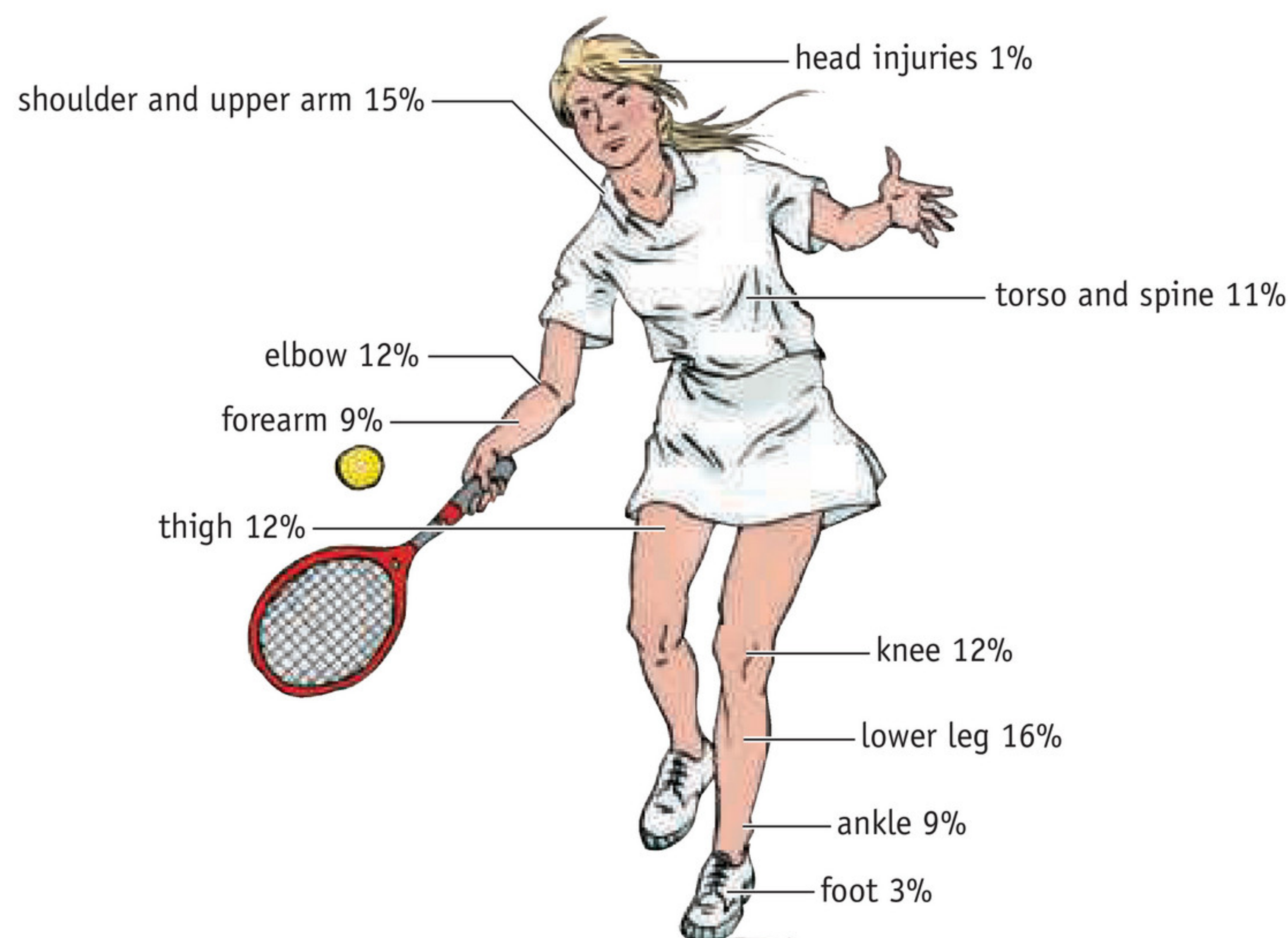
Graphs

University medical students have to memorize all the bones in the human body. A teacher in medicine wants to know whether her students can still name all the bones after they have graduated. She gives a group of students who have just graduated a picture of the human skeleton and asks them to name as many bones as possible. The former students do this test once a year for five years.

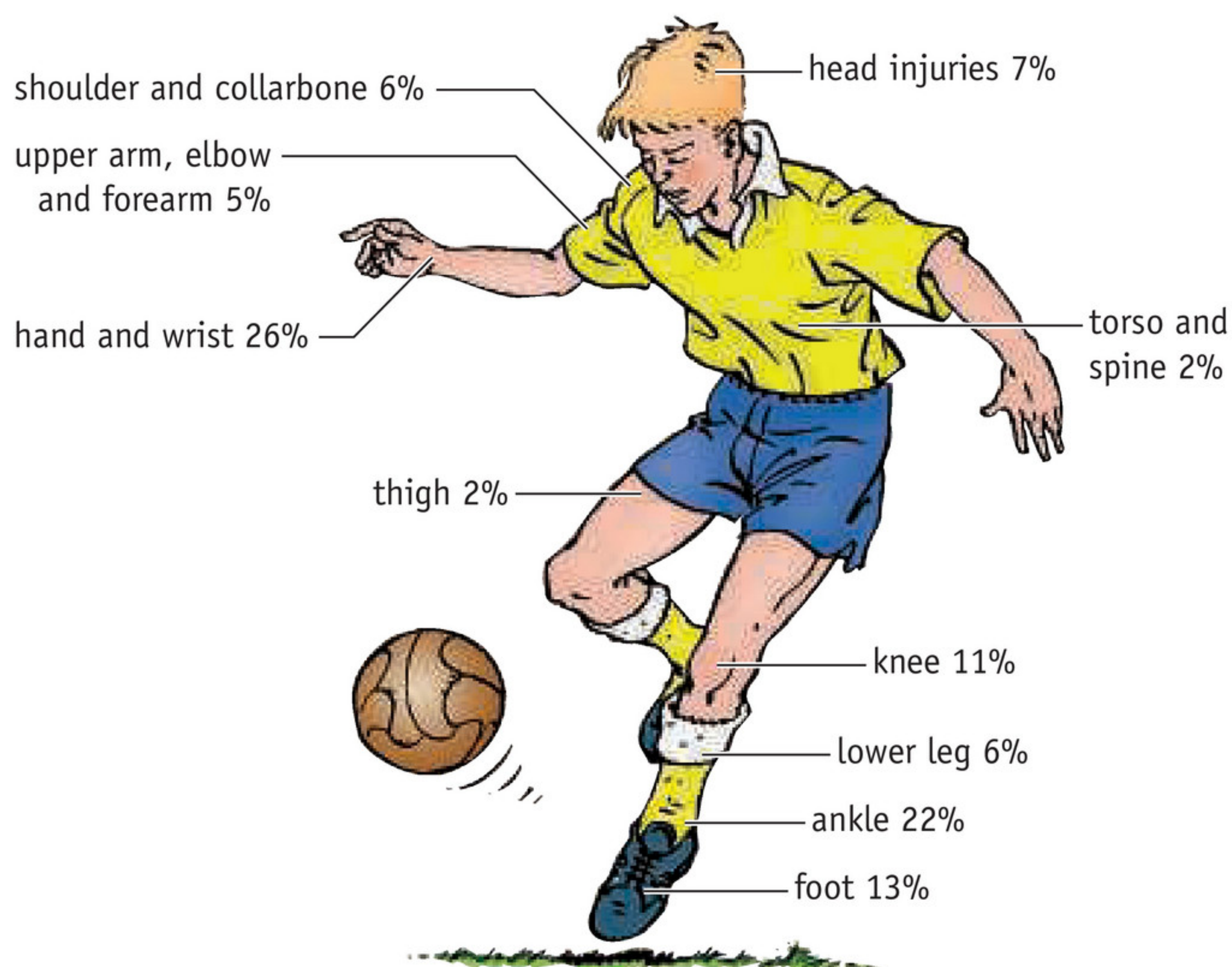
Sophie and Joe are investigating the difference between ‘early birds’ and ‘night owls’ – people who work well in the mornings or evenings. They have asked the entire first-year class to take part in their research. First, all the students were divided into two groups: the students who are more productive in the morning (early birds) and the students who are more productive in the evening (night owls). Next, each group was split into two. One half of each group had to do as many press-ups as they could in the morning, the other half just before going to bed. Sophie and Joe want to investigate whether ‘morning people’ are better at doing press-ups in the morning and ‘evening people’ better in the evening.

Fred has to give a presentation about the human body. He decides to discuss the commonest sporting injuries. After studying the literature, he found the following results: head 1%, shoulder and upper arm 15%, torso and spinal column 11%, elbow 12%, forearm 9%, thigh 12%, knee 12%, lower leg 16%, ankle 9% and foot 3%.

fig. 6 Injuries to different parts of the body.



1 when playing tennis



2 when playing football

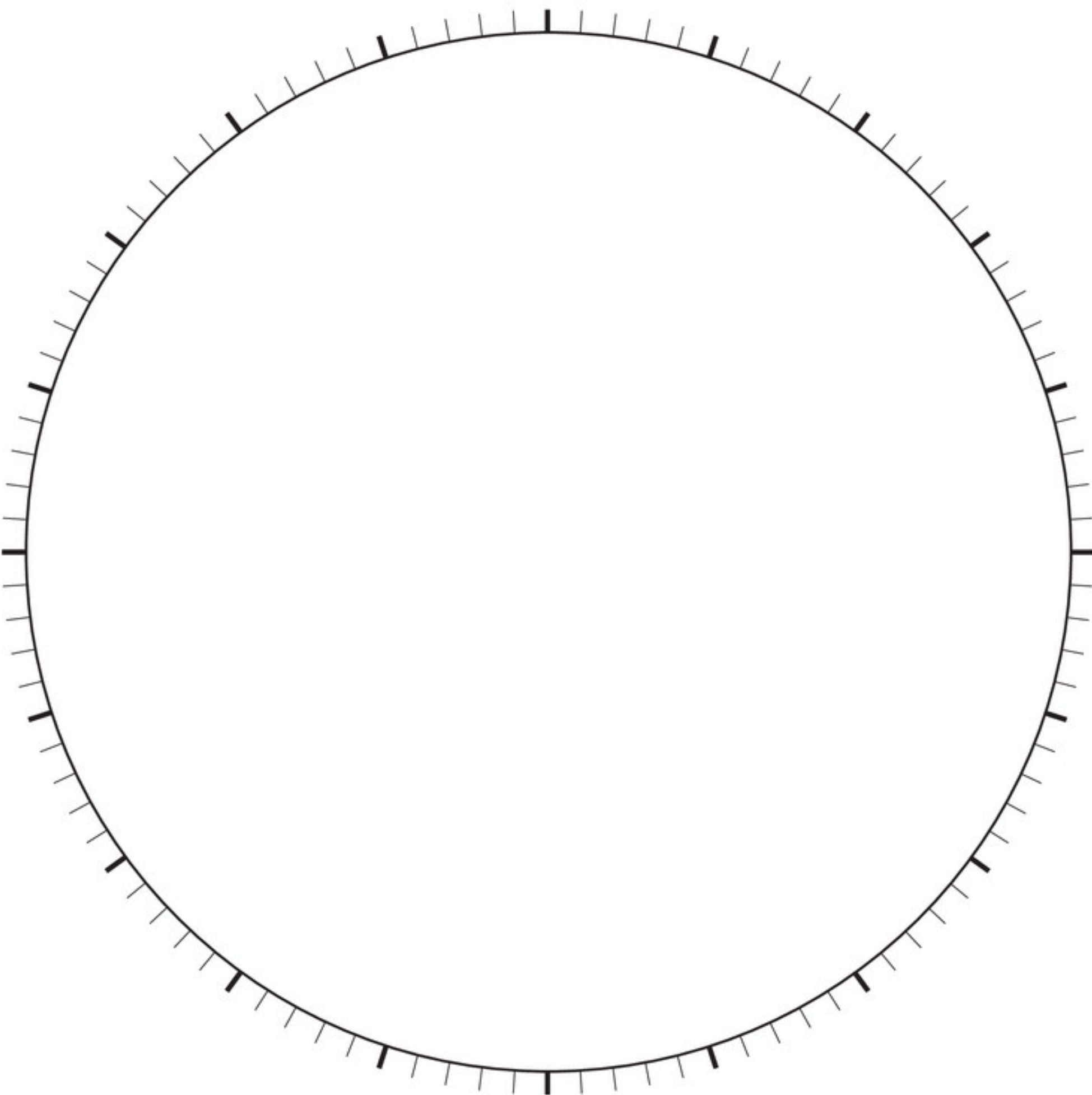
2



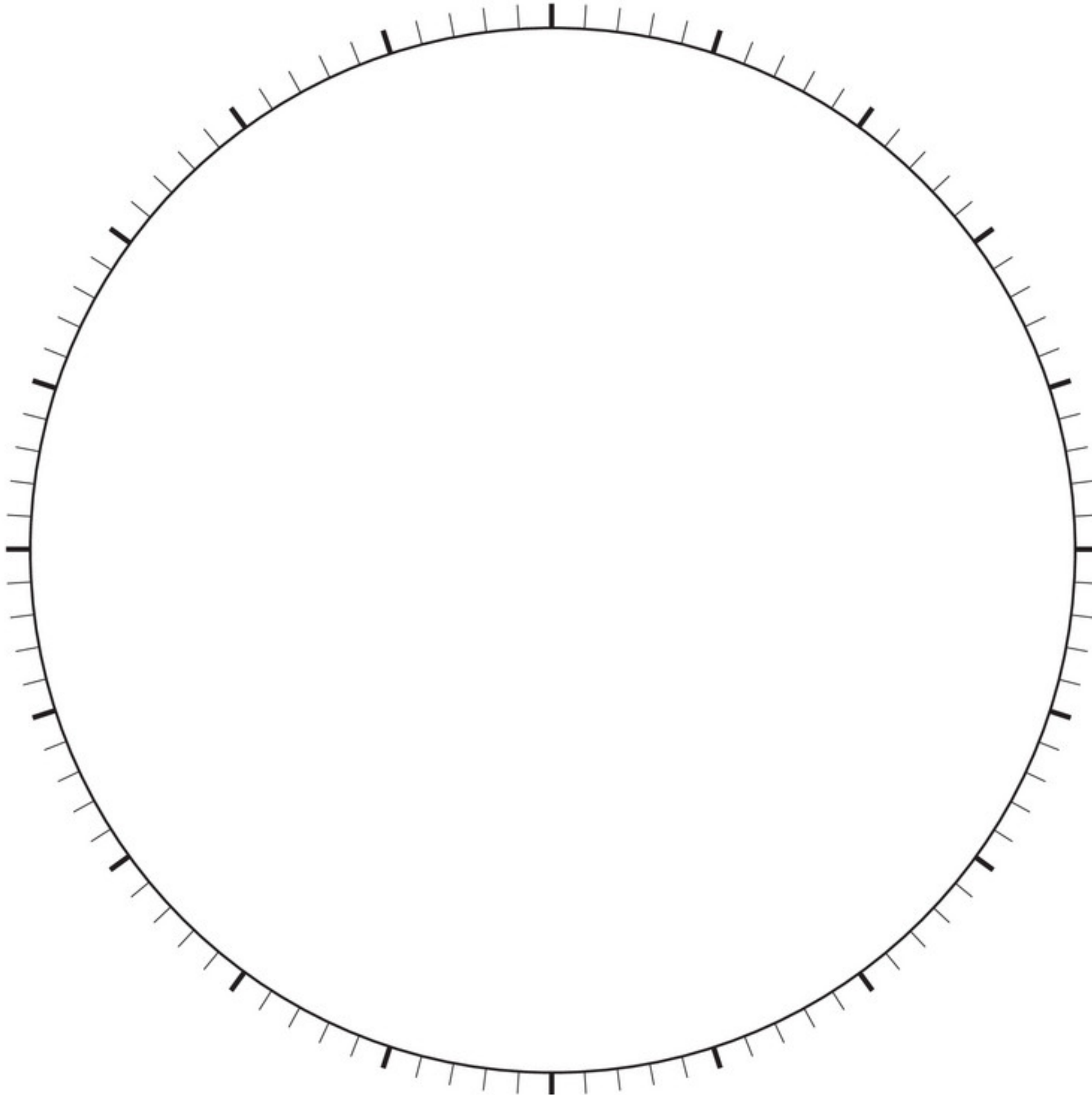
- Figure 6 has data about injuries to parts of the body when playing tennis and football. The parts of your body mentioned are the arms, legs, head and torso.
- For each body part, calculate what percentage of the total number of injuries occurs in that part of the body.
 - Put the results in the table.
 - Make a pie chart of the percentages in figures 7.1 and 7.2.

Part of the body	Injuries	
	playing tennis	playing football
arms	%	%
legs	%	%
head	%	%
torso	%	%

fig. 7



1 injuries playing tennis



2 injuries playing football

3

MAKING A WORK PLAN

► Basics 5 | ► Learning objective 4.O.19 | ► Practical activity 4

Before carrying out a science experiment, you make a work plan. A work plan describes how you want to carry out the research to answer the research question, what you need for it, and how you are going to process the results.

In biology, you do a lot of experimental research; you usually study organisms. For experiments like this, you can make a work plan based on eight questions (see figure 8). To make sure the results are reliable, take particular care with questions 3, 4 and 5.

fig. 8

Eight questions about your work plan

- 1 What will you be investigating?
- 2 What organism will you do the experiment with (and why are you using this species)?
- 3 How many organisms will you need for each group for reliable results?
- 4 What conditions are you going to subject the test group and the control group to?
- 5 How do you make sure that other factors are not having an effect?
- 6 What do you need for doing the experiment?
- 7 How will you determine the result of the experiment?
- 8 How will you represent the result of the experiment?

TEST GROUP AND CONTROL GROUP

In experimental research, you often work with a **test group** and a **control group**. The test group is exposed to the factor you want to investigate the effect of, whereas the control group is not. Suppose you are investigating the effect of drinking coke on the concentration of young people, for example. You make two groups. You give the test group coke to drink after which they do a concentration test. The members of the control group don't get coke to drink before they do the test. By comparing the results of the test group with the results of the control group, you can see the effect of the factor you were investigating.

ENOUGH ORGANISMS

If you carry out an experiment with just a single organism, the result may depend too much on random chance. That organism could be sick, for example. You should therefore always do an experiment with multiple organisms. That's not always possible at school. In that case, you can use the results of your classmates too. The more organisms you have in each group, the more reliable your results will be.

SAME CONDITIONS

The only difference should be in the factor you are investigating. All other conditions are kept the same for both groups. For example, let's say you are investigating the germination of seeds with or without water. Then you keep the groups at the same temperature and with the same amount of light. If you store the test group at a different temperature to the control group, then you will not get reliable results. Any difference between the two groups could then have been caused by the difference in temperature.

EXERCISES

1

- a** Why do you need a control group as well as the test group?
- b** Why do you need more than one organism per group?
- c** Why do you investigate groups kept in the same conditions?

2

Let's say the whole class investigates the effect of water on the firmness of herbaceous plant stems. You must think up what kind of experiment you will be doing for this. You can use test tubes and a test tube rack. You can use the stems of the white deadnettle, a herbaceous plant that can easily be found nearly all year round.

Using the eight questions in figure 8, make a work plan for this experiment.

- a** What will you be investigating?
- b** What organism will you do the experiment with (and why are you using this species)?
- c** How many organisms will you use in each group to get reliable results?
- d** What conditions are you going to expose the test group and the control group to?
- e** How can you make sure that other factors are not having an effect?
- f** What do you need for doing the experiment?
- g** How will you determine the results of the experiment?
- h** How will you present the results?

Practical activities

1

CARTILAGE AND BONE

► Basics 2 | ► Learning objective 4.2.4

 30-40 minutes

WHAT ARE YOU GOING TO DO?

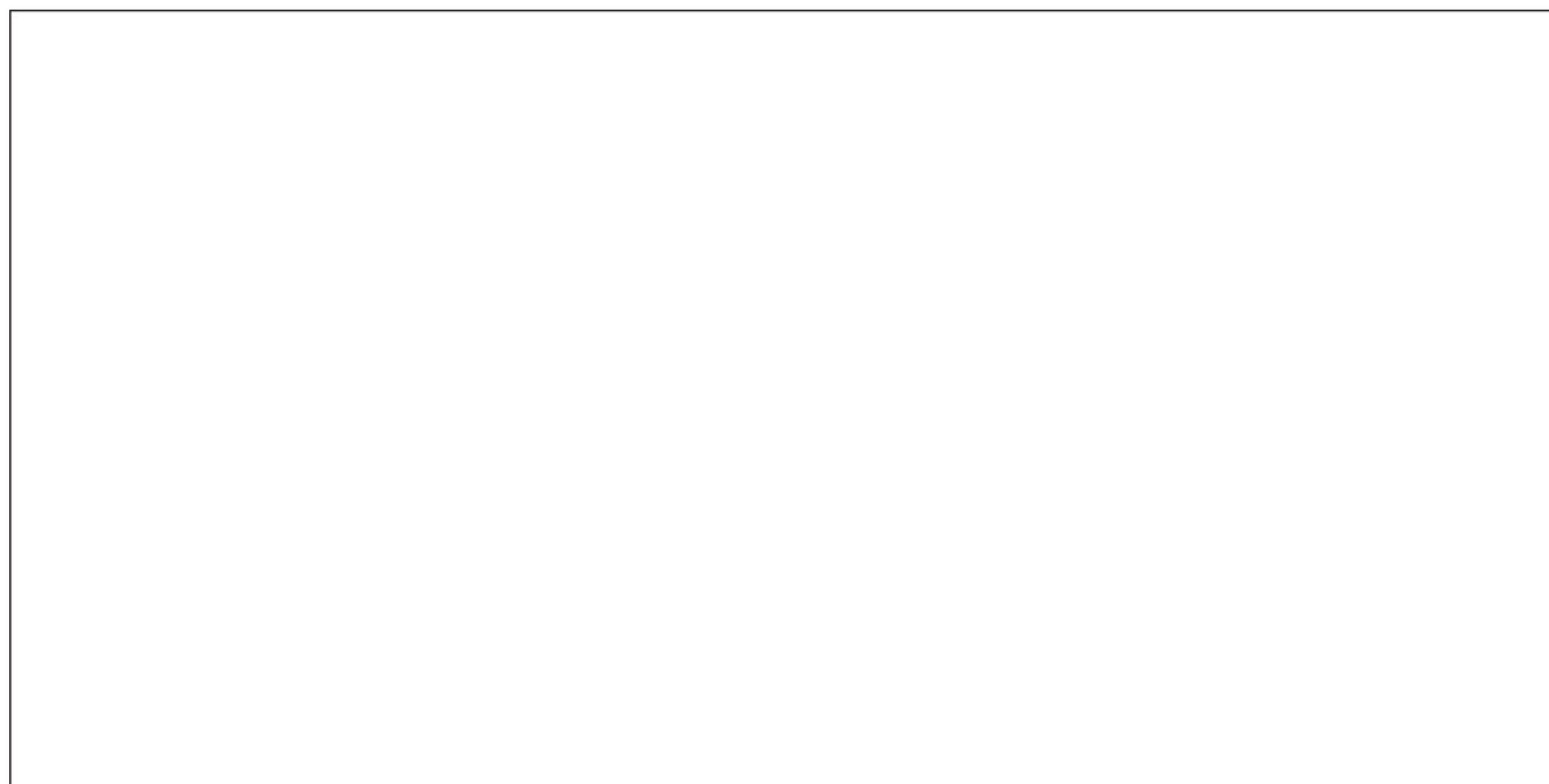
In this practical activity, you take a look at cartilage tissue and bone tissue. You will make drawings of them.

WHAT DO YOU NEED?

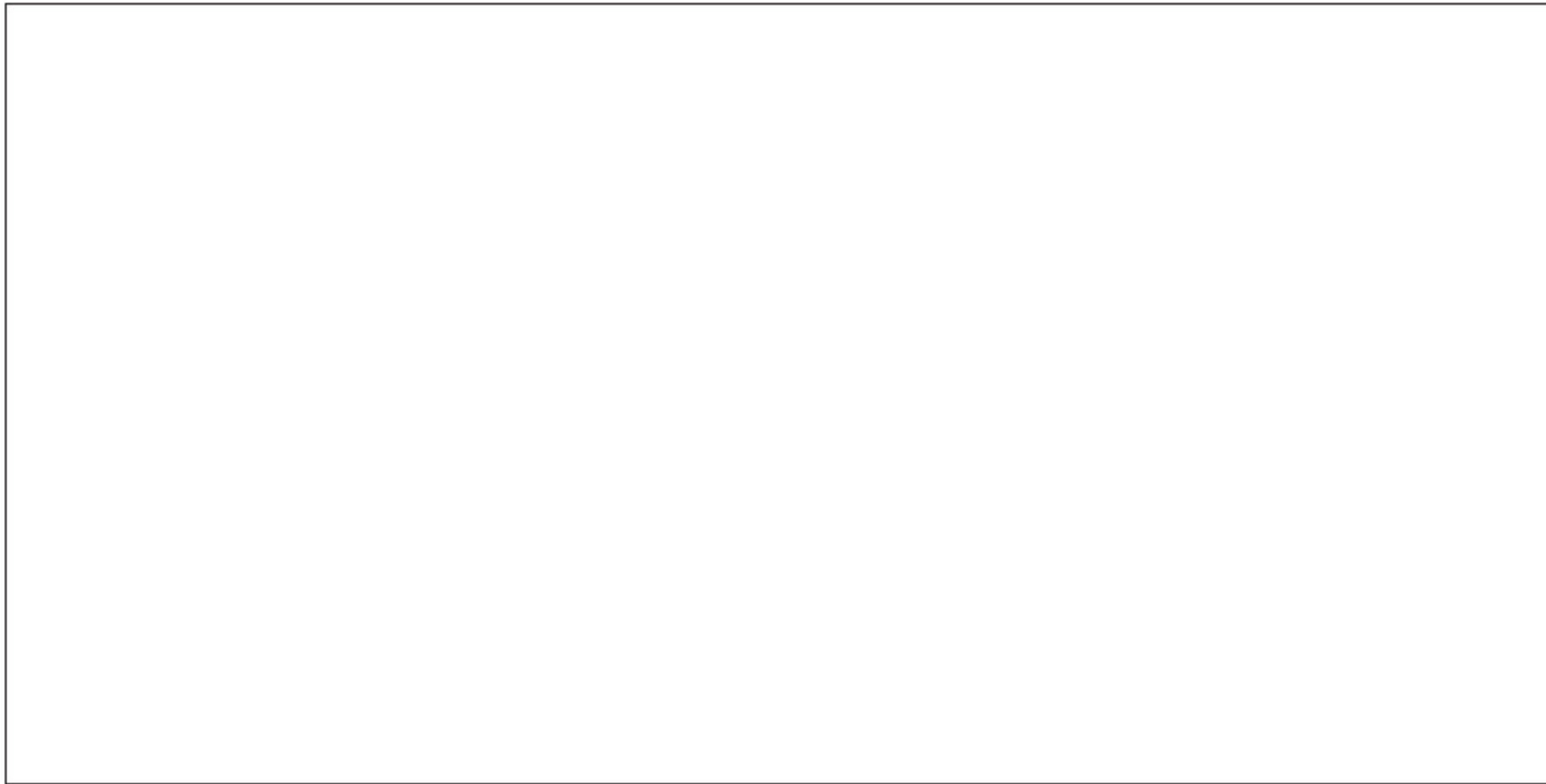
- ☐ prepared specimen slides of cartilage tissue and bone tissue
- ☐ a microscope
- ☐ preparation materials

WORKING METHOD

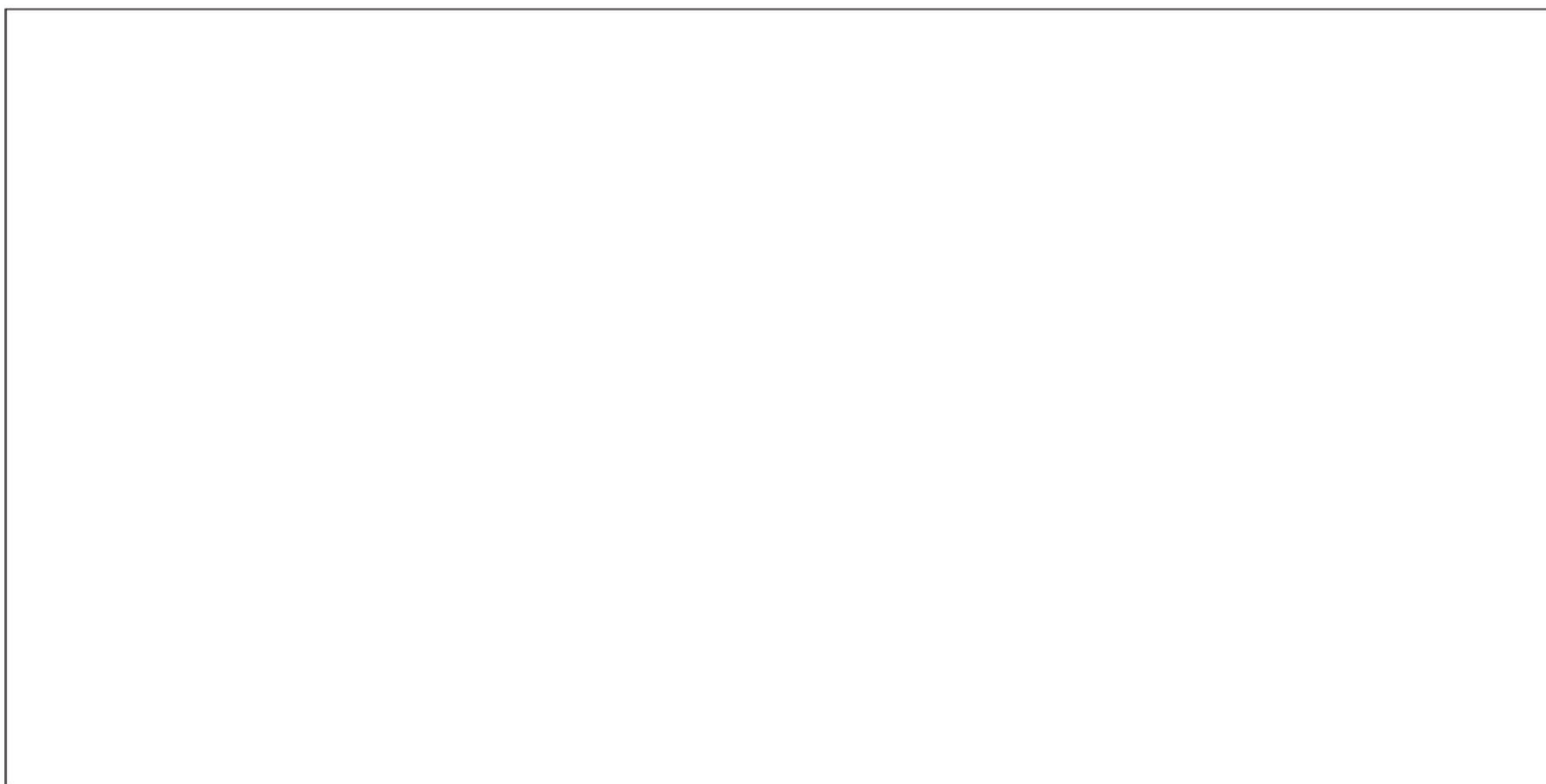
- Examine the specimen of cartilage tissue at a magnification of 100×. You see cartilage cells in the extracellular material. Examine a few cells at a magnification of 400×.
- Make a drawing of two groups of cartilage cells. Add a title and a note of the magnification of your drawing. Label: *nucleus - cartilage cell - extracellular material*.



- Examine the specimen of bone tissue at a magnification of 100×. You see bone cells in the extracellular material. The bone cells are in rings around small channels. The cells have extensions ('processes').
- Make a schematic drawing of a channel with the surrounding bone cells and extracellular material. Add a title and note the magnification next to your drawing. Label: *bone - channel - extracellular material - process*.



- Examine a few bone cells at a magnification of 400×. You will see now the processes better.
- Make a drawing of three bone cells with processes. Add a title and note the magnification next to your drawing. Label: *bone - extracellular material - process*.



2

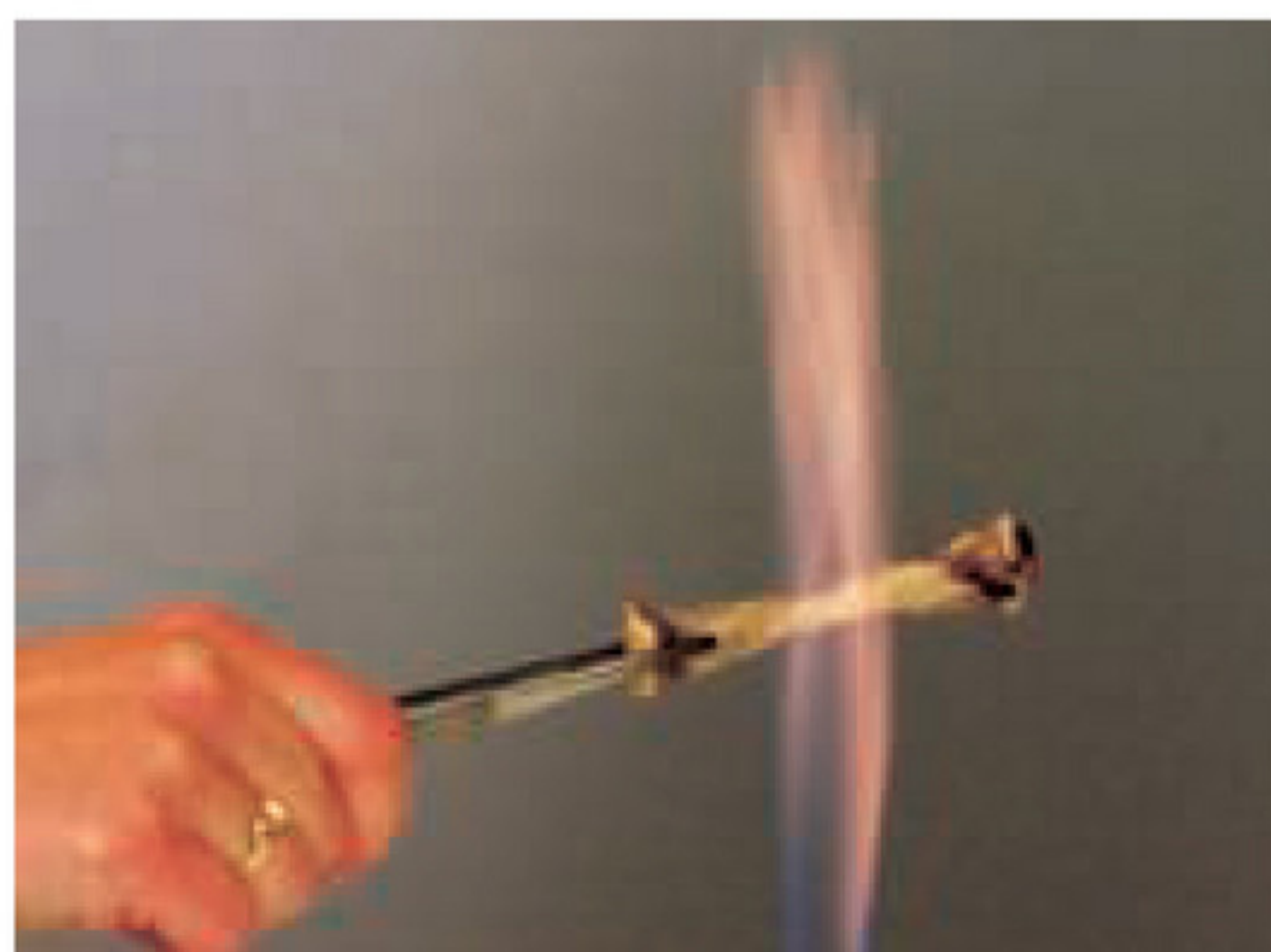
THE FUNCTION OF CALCIUM PHOSPHATE AND COLLAGEN

► Basics 2 | ► Learning objective 4.2.4

 15-20 minutes

WHAT ARE YOU GOING TO DO?

If you leave a bone for a while in a dilute hydrochloric acid solution, the calcium phosphate dissolves out of the bone. This makes the bone very flexible (see figure 1). If you hold a bone in a flame, the collagen burns away. The bone can then easily be broken (see figure 2).

fig. 1 Bones in dilute hydrochloric acid.**fig. 2** A bone in a flame.

This is a demonstration practical activity. Your teacher will show you various bones. In this practical activity, you will answer some questions about the function of calcium phosphate and collagen in bone tissue.

EXERCISES

1

Your teacher has placed a bone in a hydrochloric acid solution for some time. The bone was then rinsed clean. The hydrochloric acid dissolves the calcium phosphate from the bone.

- a** How have the strength (rigidity) and the flexibility of the bone changed?
- b** What is the function of calcium phosphate in bone tissue?

2

Your teacher has held a bone in a flame for some time. This removes the collagen from the bone tissue.

- a** How have the strength (rigidity) and the flexibility of the bone changed?
- b** What is the function of collagen in bone tissue?

3

THE ARM FLEXOR MUSCLE

► Basics 4 | ► Learning objectives 4.4.9 and 4.O.16 | ► Learning how to do research 1

 40-50 minutes

WHAT ARE YOU GOING TO DO?

When a muscle contracts, changes take place: the muscle becomes thicker.

In this practical activity, you will compare the increase in thickness between thin arms (with a small circumference) and broad arms (with a large circumference).

You do this practical activity together with a classmate.

WORKING METHOD

Carry out the exercise in the table and then complete the rest of it.

RESEARCH	INCREASE IN MUSCLE THICKNESS WHEN IT CONTRACTS																																																																																
Study question	Is the percentage increase in muscle thickness greater in pupils with thin arms or pupils with thick arms?																																																																																
Hypothesis																																																																																	
What do you need?	☐ a tape measure																																																																																
Work plan	• Each measure the circumference of the other person's upper arm (the distance around it) when the arm is straight and when it is bent. Measure it at the thickest point (see figure 3). • Write down the data in a notepad. • Collect the data of eight other pupils.																																																																																
Results	• Complete the table. • Determine which pupils have smaller and larger arm circumferences. • Calculate the averages for the pupils with thick arms and the pupils with thin arms. <table><thead><tr><th rowspan="2">Pupil</th><th rowspan="2">Arm size large / small</th><th colspan="2">Upper arm circumference (in cm)</th><th rowspan="2">Increase (in cm)</th><th rowspan="2">Increase (in %)</th></tr><tr><th>straight</th><th>bent</th></tr></thead><tbody><tr><td>yourself</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td></td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>average of five pupils with bigger arms</td><td></td><td></td><td></td><td></td><td></td></tr><tr><td>average of five pupils with smaller arms</td><td></td><td></td><td></td><td></td><td></td></tr></tbody></table>	Pupil	Arm size large / small	Upper arm circumference (in cm)		Increase (in cm)	Increase (in %)	straight	bent	yourself																																																												average of five pupils with bigger arms						average of five pupils with smaller arms					
Pupil	Arm size large / small			Upper arm circumference (in cm)				Increase (in cm)	Increase (in %)																																																																								
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average of five pupils with bigger arms																																																																																	
average of five pupils with smaller arms																																																																																	
Conclusion																																																																																	

fig. 3



1 measured with the arm straight



2 measured with the arm bent

EXERCISE

1

- a Why is it important to put all the data in a table?
- b You can make a graph using the data in a table.
Why don't you need to do that for this practical activity?
- c When is it useful to make a graph?

4

DOUBLE S-SHAPE

► Basics 5 | ► Learning objective 4.O.19 | ► Learning how to do research 3

 40-50 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity you are going to set up and carry out an investigation. You will be investigating the effect that the shape of the spinal column has.
The table gives the research question, the hypothesis and what you need for the practical activity.

WORKING METHOD

In the table, write down a work plan for testing the hypothesis. Ask your teacher to check your work plan. They might give you some tips on how to improve your work plan. Once your teacher has approved your design, you can carry out the work plan. Write down your results in the table and the conclusion that you can draw from them.

RESEARCH	THE FUNCTION OF THE SHAPE OF THE SPINAL COLUMN
Study question	What is the advantage of the double S-shape of the spinal column?
Hypothesis	The double S-shape transmits impacts less strongly than other shapes.
What do you need?	☐ 3 pieces of steel wire ☐ 3 wooden blocks with holes for a steel wire ☐ 3 wooden beads (see figure 4) 
Work plan	..... ..... ..... ..... ..... ..... ..... ..... ..... ..... ..... ..... ..... ..... .....

Results								
								
								
	<table border="1"><tr><th>How much does it wobble?</th><th>Model</th></tr><tr><td>barely wobbles</td><td></td></tr><tr><td>wobbles a bit</td><td></td></tr><tr><td>wobbles a lot</td><td></td></tr></table>	How much does it wobble?	Model	barely wobbles		wobbles a bit		wobbles a lot
How much does it wobble?	Model							
barely wobbles								
wobbles a bit								
wobbles a lot								
Conclusion								
								
								
								
								

5

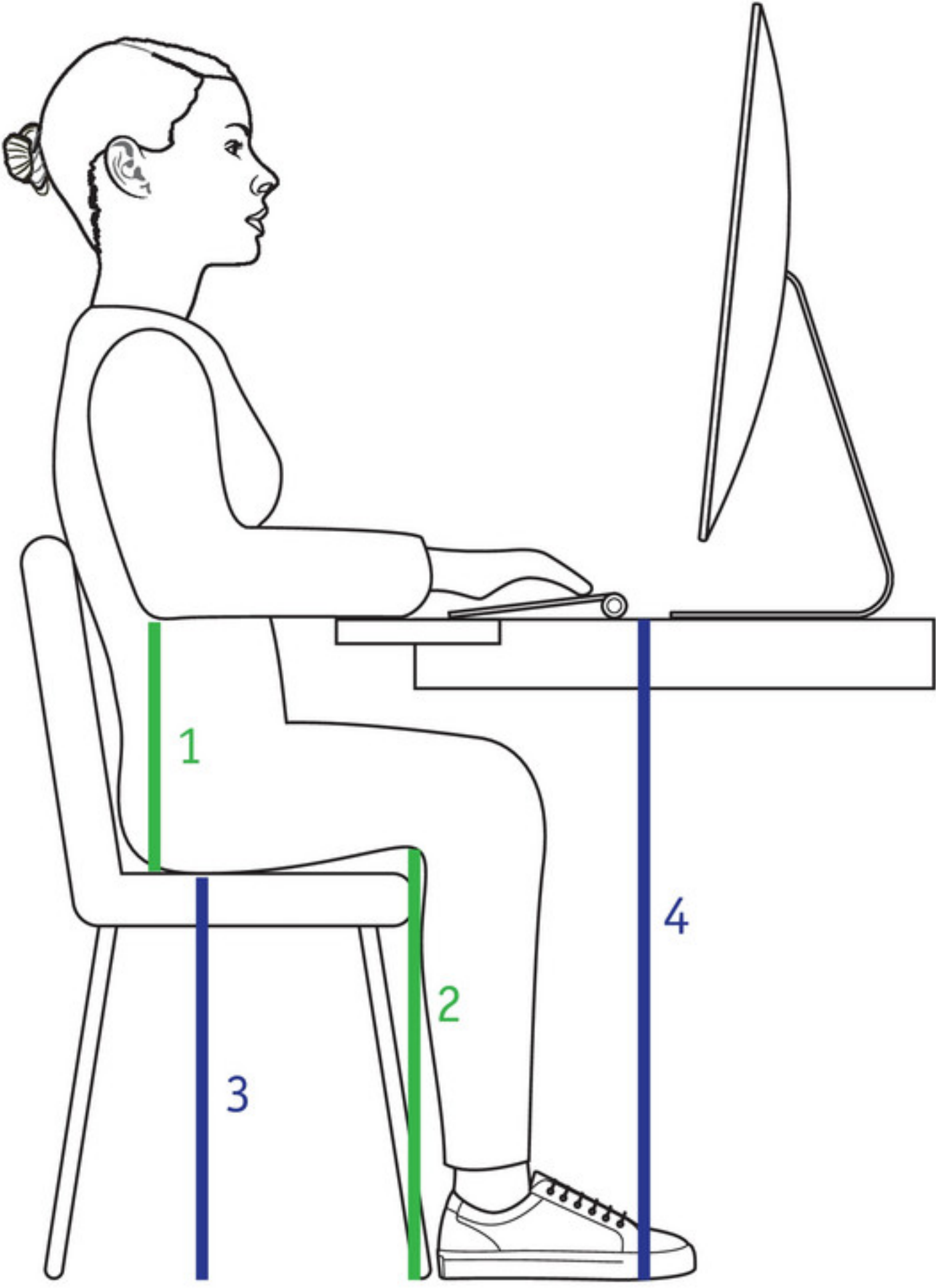
SITTING POSTURE AT SCHOOL

► Basics 5 | ► Learning objectives 4.5.11 and 4.O.16 | ► Learning how to do research 1

 20-30 minutes

WHAT ARE YOU GOING TO DO?
A good sitting posture can prevent spinal column complaints. In this practical activity, you will be investigating your sitting posture at school. You do this practical activity together with a classmate. Carry out the exercise in the table and then complete the rest of it.

fig. 5 Sitting posture at school.



RESEARCH	MY SITTING POSTURE AT SCHOOL																		
Study question	Is my sitting posture at school good?																		
Hypothesis																			
What do you need?	☐ a tape measure																		
Work plan	• Sit up straight and keep your arms bent (see figure 5). Get your classmate to measure the distance from the underside of your elbow to the chair seat (1). Write down this distance. • Place your feet flat on the floor. Get your classmate to measure the distance from the back of your knee to the floor (2). Write down this distance. • Measure the height of your chair (3). Measure the height of your desk too (4). Write down these heights. • Determine what would be the ideal height of your desk and chair for you: – For the ideal height of the desk, add together the distance from the back of your knee to the floor plus the distance from your elbow to the chair seat. – The ideal height of your chair is the distance from the back of your knee to the floor.																		
Results	Put all the data in the table. <table><tbody><tr><td>1</td><td>Distance between elbow and seat</td><td>..... cm</td></tr><tr><td>2</td><td>distance between back of the knee and the floor</td><td>..... cm</td></tr><tr><td>3</td><td>height of my chair</td><td>..... cm</td></tr><tr><td>4</td><td>height of my desk</td><td>..... cm</td></tr><tr><td></td><td>ideal height of my chair (2)</td><td>..... cm</td></tr><tr><td></td><td>ideal height of my desk (1 + 2)</td><td>..... cm</td></tr></tbody></table> • Is your chair at the right height, or is it too low or too high? Explain your answer. • Is your desk at the right height, or is it too low or too high? Explain your answer.	1	Distance between elbow and seat	 cm	2	distance between back of the knee and the floor	 cm	3	height of my chair	 cm	4	height of my desk	 cm		ideal height of my chair (2)	 cm		ideal height of my desk (1 + 2)	 cm
1	Distance between elbow and seat	 cm																	
2	distance between back of the knee and the floor	 cm																	
3	height of my chair	 cm																	
4	height of my desk	 cm																	
	ideal height of my chair (2)	 cm																	
	ideal height of my desk (1 + 2)	 cm																	
Conclusion																			

6 COMPARING MUSCLE MASS AND STRENGTH

► Basics 6 | ► Learning objectives 4.6.12 and 4.O.16 | ► Learning how to do research 1 and 2

 40-50 minutes

WHAT ARE YOU GOING TO DO?

In most people, one arm is stronger than the other. We call the arm you write with the dominant arm. If you are right-handed your right arm is dominant and if you are left-handed your left arm is dominant.

In this practical activity, you will compare your dominant arm with your other arm.

You do this practical activity together with a classmate.

Carry out the exercise in the table and then complete the rest of it.

RESEARCH	COMPARING MUSCLE MASS AND STRENGTH
Study question	Is someone’s dominant arm also their stronger arm?
Hypothesis	..... .....
What do you need?	☐ a tape measure ☐ scales
Work plan	• Sit upright at a table. Place your hands on the tabletop with your palms down. Make sure that your elbows are tightly next to your body and that your forearms are at an angle of 90° to your upper arms. • Press down as hard as possible on the table and get your classmate to measure the circumference of your upper arm muscles with the tape measure. Be careful only to use your upper arm and forearm muscles. So don’t lean forwards to exert more force. Write down the results. • Let your classmate do the same. Measure the circumference of their upper arm muscles and write down the measurements. • Put the scales on the table. • Sit upright at the table. Adjust the height of the stool or sit on some books until your forearms and upper arms form a right angle again. • Place one of your hands on the scales. The palm of your hand should be facing downwards again. Press down as hard as you can with your hand on the scales. Be careful only to use your upper arm and forearm muscles; don’t lean forwards. Let your classmate read how much force you are exerting and write down the measurement. • Repeat the measurement with your other hand. • Let your classmate do the same and write down their measurements.
Results	• Collect your results and the results of your classmate and four other pupils. • Present the results in a table. Calculate the average result as well.
Conclusion	..... .....

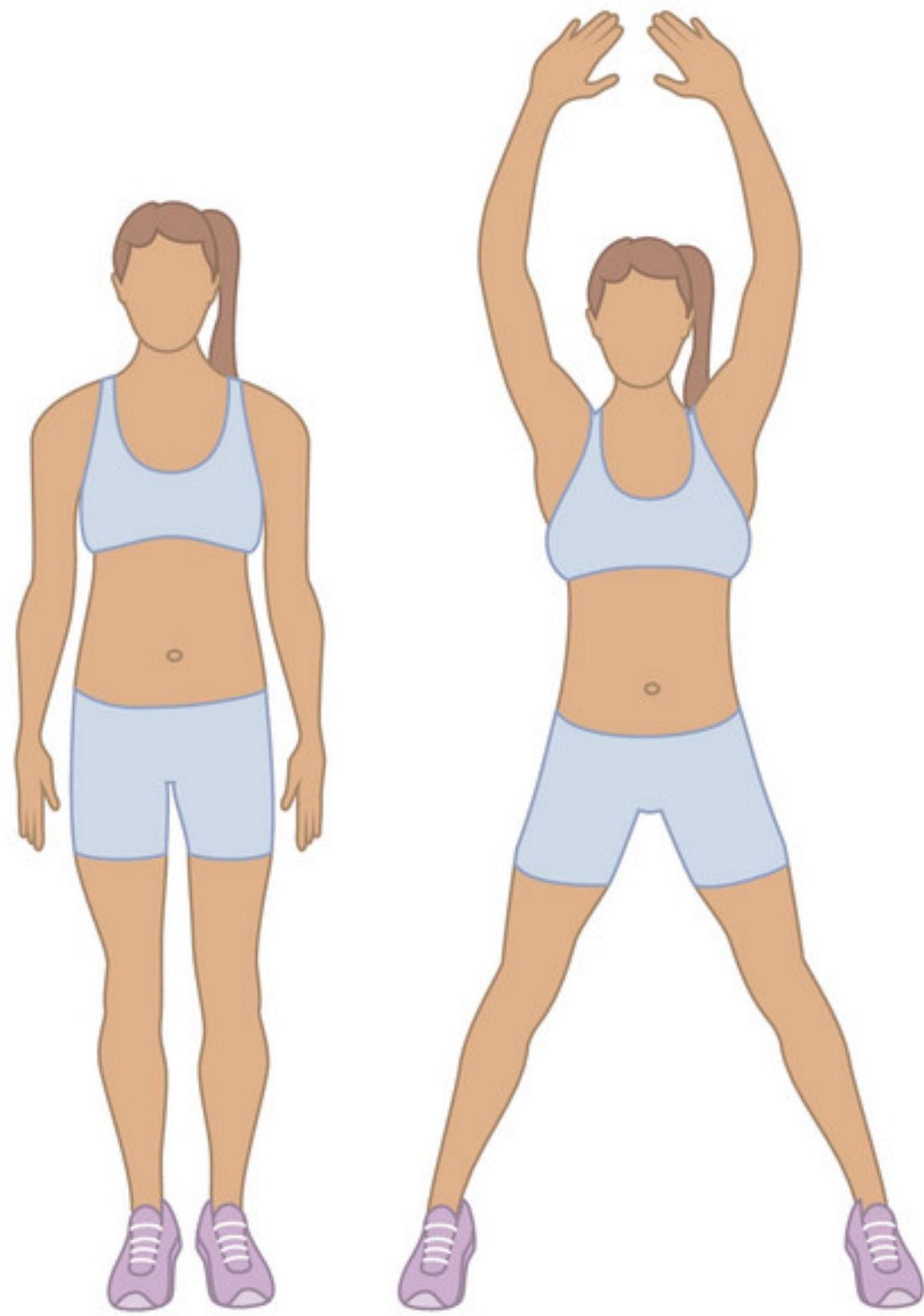
7 PLAYING SPORTS AND HEART RATE

► Basics 6 | ► Learning objectives 4.6.13, 4.O.17 and 4.O.18 | ► Learning how to do research 2

 50 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will investigate what effect the number of hours spent playing sports in a week has on your heart rate while playing sports. You will use data from the whole class.
You do this practical activity together with a classmate.

RESEARCH	COMPARING MUSCLE MASS AND STRENGTH
Study question	Does the number of hours spent playing sports in a week affect your heart rate while playing sports?
Hypothesis	..... .....
What do you need?	☐ a stopwatch ☐ a heart rate monitor
Work plan	• Write down how many hours you play sports (on average) in a week and do the same for a classmate. • Put on the heart rate monitor. Do jumping jacks for 30 s next to your desk (see figure 6). Your classmate should time the 30 s using the stopwatch. • Immediately afterwards, read off your heart rate using the heart rate monitor. Write down your heart rate. • Get your classmate to do jumping jacks for 30 s. Time them with the stopwatch. As soon as the 30s finishes, read off the heart rate using the heart rate monitor. Write down this heart rate. fig. 6 Jumping jacks. 
Results	• Make a table for filling in the name of each pupil in the class, the number of hours a week they play sports and their heart rate after 30 s of jumping jacks. Write down the names of all the pupils in the table. • Write down your results and your classmate’s results in the table. Collect the results of the other pupils in your class and write them in the table. • Calculate the average heart rate for the different numbers of hours playing sports. Write down these averages in a new table. • Think what kind of graph you can best make to show your results. Ask your teacher for help if necessary. Make the graph.
Conclusion	..... .....

8

MAKING FOOTPRINTS

▶ Extra 7 | ▶ Learning objective 4.7.14

 50 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will examine the footprint of a foot carrying weight and a foot not carrying weight.

WHAT DO YOU NEED?

- ☐ a washing-up bowl full of water
- ☐ a piece of cardboard (not too smooth)
- ☐ a tea towel
- ☐ a felt-tipped pen

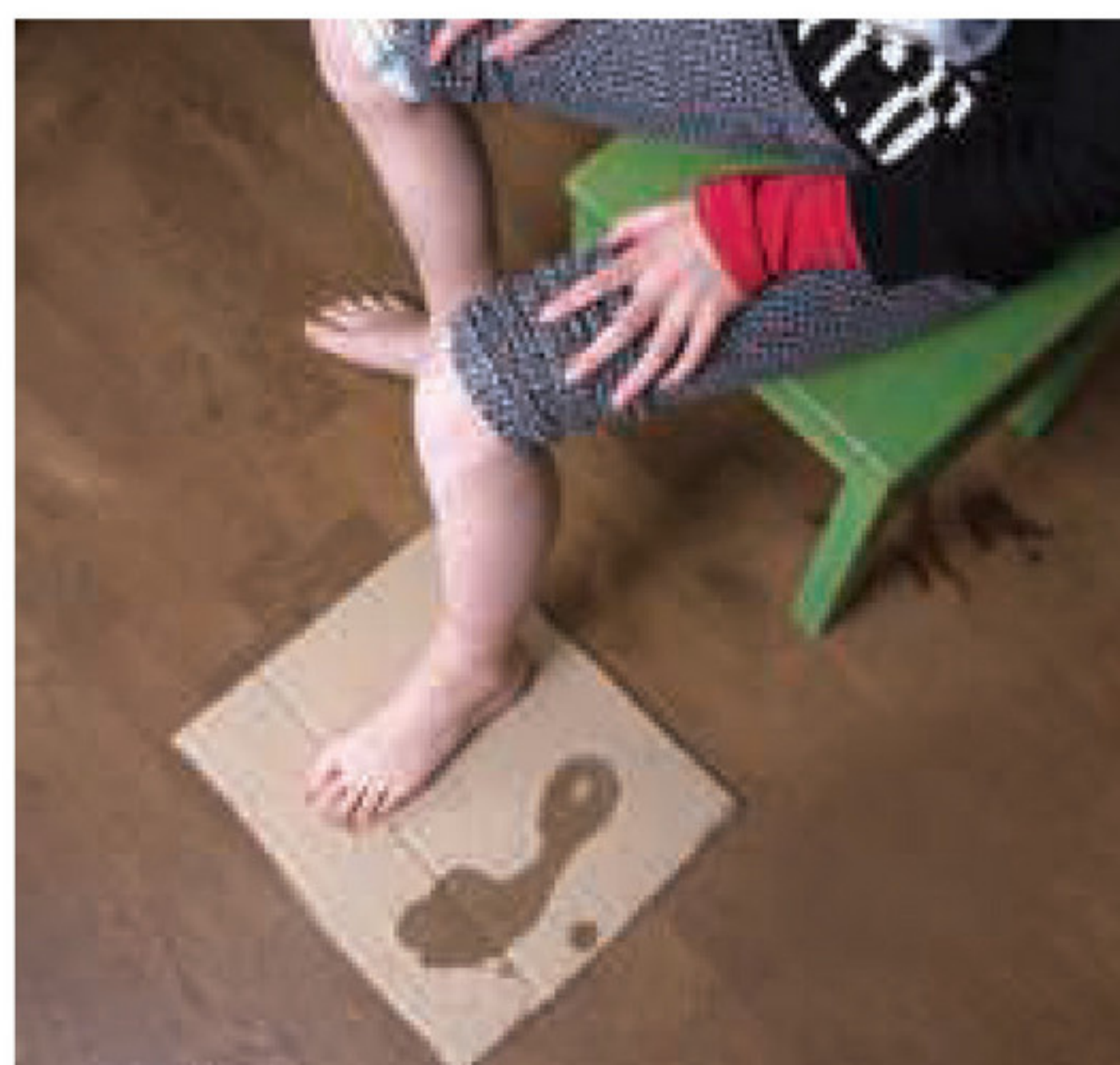
WORKING METHOD

- Study figure 7.
- Make a footprint of your left foot. To do that, wet the sole of your left foot and stand on that foot on the left-hand half of the piece of card. Because you are standing, there is *weight* on the foot.
- In the same way, make a print of your left foot on the right-hand half of the piece of cardboard, but this time *without any weight*. Sit on a chair to do this.
- Leave the footprints to dry. Use the felt-tipped pen to draw the outline of the footprints, just before the cardboard dries out.

fig. 7



1 making a footprint of a loaded foot



2 making a footprint of an unloaded foot

EXERCISE

1

- a What difference can you see between the print of a foot with weight on it and a foot without weight?
- b Explain what causes this difference.
- c What kind of feet do you have: normal, highly arched or flat? Have a look at the print of your loaded foot to see.

Summary

BASICS 1

THE SKELETON

1 You know the parts of the body.

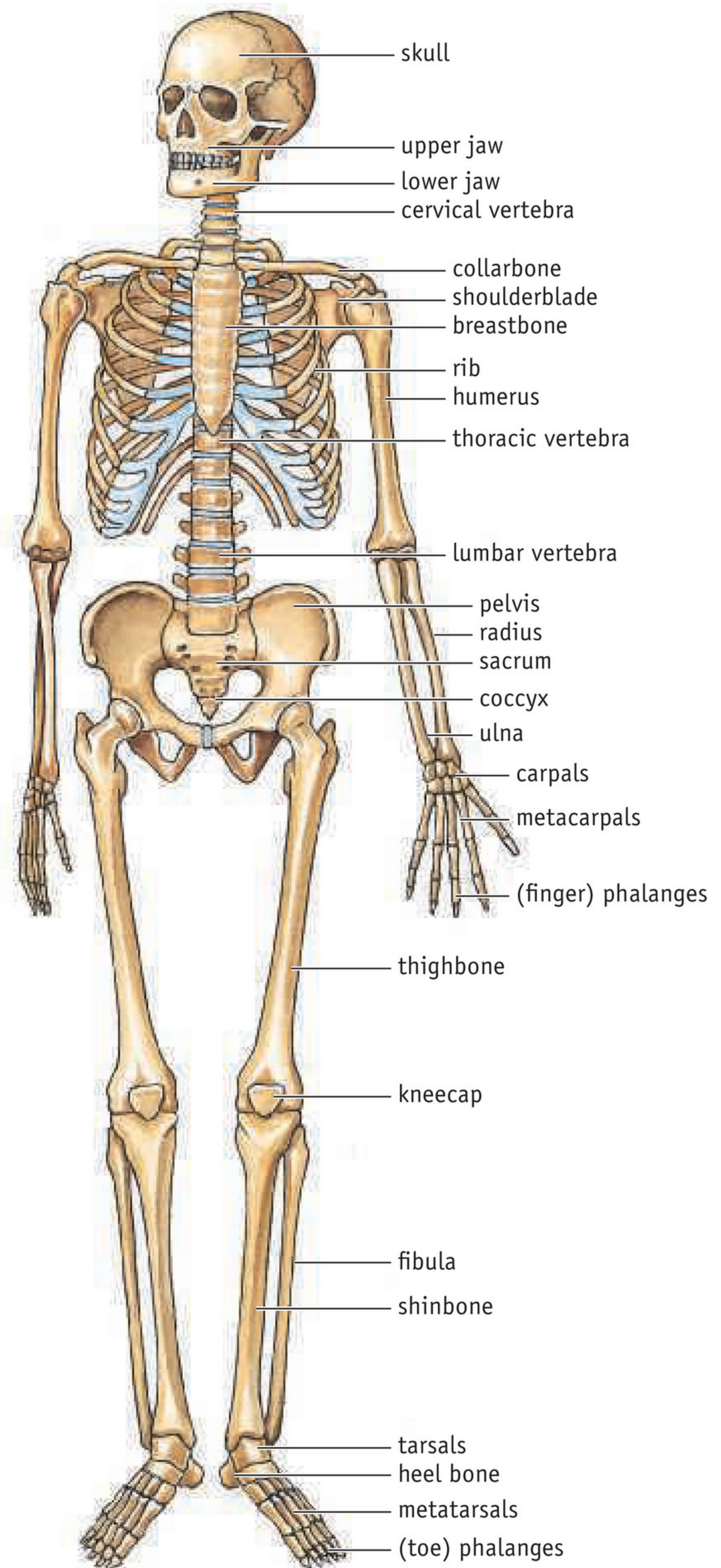
- Parts of the body: head, torso, limbs.
 - limbs: arms and legs

2 You can name the bones in a picture of the skeleton.

- The skeleton consists of bones.

3 You can name the functions of the skeleton.

- Four functions:
 - giving sturdiness, so you can stand upright
 - making movement possible
 - providing protection for vulnerable organs
 - giving the body its shape
- The shape of the skeleton and the bones is related to their function.



BASICS 2

THE STRUCTURE OF BONES

4 You can describe the structure of bone tissue and cartilage tissue.

- Cartilage tissue is sturdy and very flexible.
 - Cartilage cells are in groups clustered together in elastic extracellular material.
 - Cartilage contains a lot of collagen.
- Bone tissue is very sturdy and a little bit flexible.
 - Bone cells are arranged in the extracellular material in rings around small channels.
 - Calcium phosphate in the extracellular material provides the firmness (rigidity). Calcium phosphate dissolves in hydrochloric acid.
 - Collagen in the extracellular material provides flexibility. Collagen burns in a flame.

5 You can describe how the composition of the bones changes during someone's life.

- Over the course of your life, the amount of collagen decreases and the amount of calcium phosphate increases.
 - Babies' bones mainly consist of cartilage tissue. There are gaps – the fontanelles – between the bones of the skull.
 - As they get older, the cartilaginous tissue changes to bone tissue. The fontanelles close up.
 - children: bone tissue with a lot of collagen and not much calcium
 - elderly people: bone tissue with not much collagen and a lot of calcium
- Adults have cartilage:
 - in the outer ears
 - in the nose
 - between the ribs and the breastbone
 - between the vertebrae of the spinal column

BASICS 3

BONE CONNECTIONS

6 You can describe the bone connections.

- Bone connections that do not allow movement:
 - fused together (e.g. sacrum, coccyx)
 - sutured (e.g. skull bones)
- Bone connections that allow movement:
 - cartilage, some movement possible (e.g. between the ribs and the breastbone)
 - joint, a lot of movement possible (e.g. between the bones of the hand)

7 You can describe the structure of a joint.

- In a joint, the ball-shaped bone rotates in the socket bone.
- Layers of cartilage:
 - prevent wear and tear
 - make movements smoother
- Joint capsule:
 - keeps the bones in place
 - secretes synovial fluid, which lets the bones move smoothly
- Ligaments: extra reinforcement around a joint.

8 You can describe how a ball-and-socket joint, a hinge joint and a pivot joint work.

- Ball-and-socket joint:
 - rotating motion possible (e.g. shoulder joint, hip joint)
- Pivot joint:
 - one bone rotates along its lengthwise axis around the other (e.g. radius and ulna)
- Hinge joint:
 - only movement back and forth is possible (e.g. elbow joint, knee joint)

BASICS 4

MUSCLES

9 You can explain how the muscles work.

- Muscular system: all skeletal muscles together.
- Skeletal muscles are attached to the bones by tendons.
 - Attachment site: the place where a muscle is attached to the bone.
 - Tendons cannot contract.
- Muscles can move a bone by contracting.
 - When a muscle contracts, it becomes shorter and thicker.
 - The muscle pulls the bones towards each other.
- Antagonistic pair: two muscles that have opposite effects.
 - Two muscles are needed to move a bone, e.g. the biceps (arm flexor muscle) and triceps (arm extensor muscle).

10 You can give examples of voluntary and involuntary muscle movements.

- In addition to the skeletal muscles, you also have muscles in your organs.
 - These muscles move without you being aware of it, e.g. the muscles in your stomach, intestines, heart and skin.

BASICS 5

THE SPINAL COLUMN

11 You can state what is a good posture and why that is important.

- Double S-shape: the shape of the spinal column.
 - The vertebrae are connected to one another by intervertebral discs.
 - Intervertebral disc: gel-like core surrounded by cartilage.
- Posture: your position when you stand and sit.
 - In good posture, the spinal column has a double S-shape.
 - Good sitting position: the arms and legs form right angles.
- Crooked/hunched back: you can get this from looking down at a screen a lot.
- Good practice when using screens:
 - Hold your head upright.
 - Don't use the screen for more than half an hour at a time.
 - Lie on your stomach when reading, watching TV, gaming or using your phone.
 - Sit at the front of your chair with one foot bent backwards.
- You can prevent back problems by lifting loads properly.

BASICS 6

HEALTHY EXERCISE

12 You know that muscles get stronger through training.

- Muscles get thicker if you use them a lot.
 - They can then exert more force (perform better).
 - You are less likely to get an injury (damage).
- Muscle pain: from waste materials building up in the muscles.
 - Warming up, stretching exercises and cooling down help prevent muscle pain.
 - Training more often reduces the risk of muscle pain.

13 You can explain why exercise is good for your health.

- Exercise is good for your health:
 - It relaxes you.
 - It improves your fitness.
 - It helps prevent physical problems.
- Exercise helps your motor skills:
 - Your coordination improves.
 - The speed and accuracy of your movements improve.
- Motor memory: lets you coordinate a movement correctly without consciously moving your muscles (e.g. cycling).

- RSI (repetitive strain injury): injury from repeated movements.
 - pain in the shoulders, arms, neck and/or head
 - Starts with tingling, fatigue and sensitivity.
 - Moving around regularly and a good posture reduce the risk of complaints.

EXTRA 7

BONE SHAPES AND FUNCTIONS (IN DEPTH)**14 You can describe the relationship between the shape and function of bones.**

- There are a lot of similarities between the skeletons of humans and other mammals.
 - Certain bones are often missing in the skeletons of many mammals, for example the kneecap.
 - The differences (shape) are related to differences in the way they live (function).
- The shape of an animal's feet is related to how that animal moves.
 - plantigrades: walk on the whole of the sole of the foot, e.g. bears, humans
 - digitigrades: walk on the toes, e.g. cats
 - unguligrades: walk on the tips of the toes (the hooves), e.g. horses
- The sole of your foot is arched.
 - This shape makes your feet better able to support weight (function).

EXTRA 8

INJURIES (EXTENSION)**15 You can name the causes and consequences of some injuries.**

- Injury: damage to muscles, bones or joints.
 - causes: e.g. rough/foul play, insufficient training, too tired, pushing yourself too far, bad weather, poor sports kit
- Muscle strain: damage to a muscle.
 - cause: overexertion or a sudden movement
- Fracture: a bone breaks into two or more pieces.
 - Setting a bone: putting the parts of the broken bone in the right position.
 - The parts of the bone then grow together again.
- Runner's knee: a meniscus in the knee joint is damaged.
 - cause: e.g. a rotation of the body while the lower leg stays in place
 - A damaged meniscus often requires surgical treatment.
- Bruises (contusions): damage to tissue from a fall, blow or kick.
 - bruising: internal bleeding
 - swelling: accumulation of fluid
- You can apply something cold to reduce the swelling and the pain.
- Sprain: bruising of the joint, damage to the joint capsule and the ligaments, e.g. a sprained ankle.
 - If the sprain is severe, the joint capsule and the ligaments may tear.
- Dislocation: the ball-shaped bone comes out of the socket, e.g. the elbow out of the socket.

RESEARCH

LEARNING HOW TO DO RESEARCH & PRACTICAL ACTIVITIES**16 You can carry out accurate measurements.****17 You can present your results in a bar chart, line graph or pie chart.****18 You can determine which kind of graph is best suited to showing your results.****19 You can make a work plan for a practical activity (with help).**

 Go to the *Flash cards* and the *Diagnostic test*.

5

Perception, behaviour and regulation

Your senses let you keep track of your environment. They let you respond to what is going on around you. Your responses are your behaviour. Responses to signals also happen inside your body.

BASICS

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EXTRA

7	Senses and impulses	136
8	Hearing damage	141

RESEARCH

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TO FINISH

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	Diagnostic test	





1 Perceiving your environment

LEARNING OBJECTIVES

- 5.1.1 You can describe how the senses work.

5.1.2 You are able to list the senses along with their locations and their stimuli.
- Learning how to do research 1

► Practical activity 1

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES	
	5.1.1	5.1.2
Remembering	1ac, 2	3
Understanding	1bde, 4	4
Using	5, 6a, 8	6a, 10ab
Analysing	9ab, 10c	6b, 7, 9c, 10c

You can see, hear, smell, taste and feel things around you. You use your senses for this. You also need your brain to observe things.

PERCEPTION

When you see and smell chocolate, you are using the sensory organs in your eyes and in your nose. These senses send out signals that go through your nerves to your brain. Your brain processes these signals. You then know that there is chocolate in front of you: you perceive the chocolate (see figure 1).

fig. 1 Sight and smell.



You use your senses to perceive your environment. A **sense** is an organ that reacts to certain **stimuli** from the environment. Examples of stimuli are light, sounds, smell and contact. Because your senses receive stimuli, you can observe things.

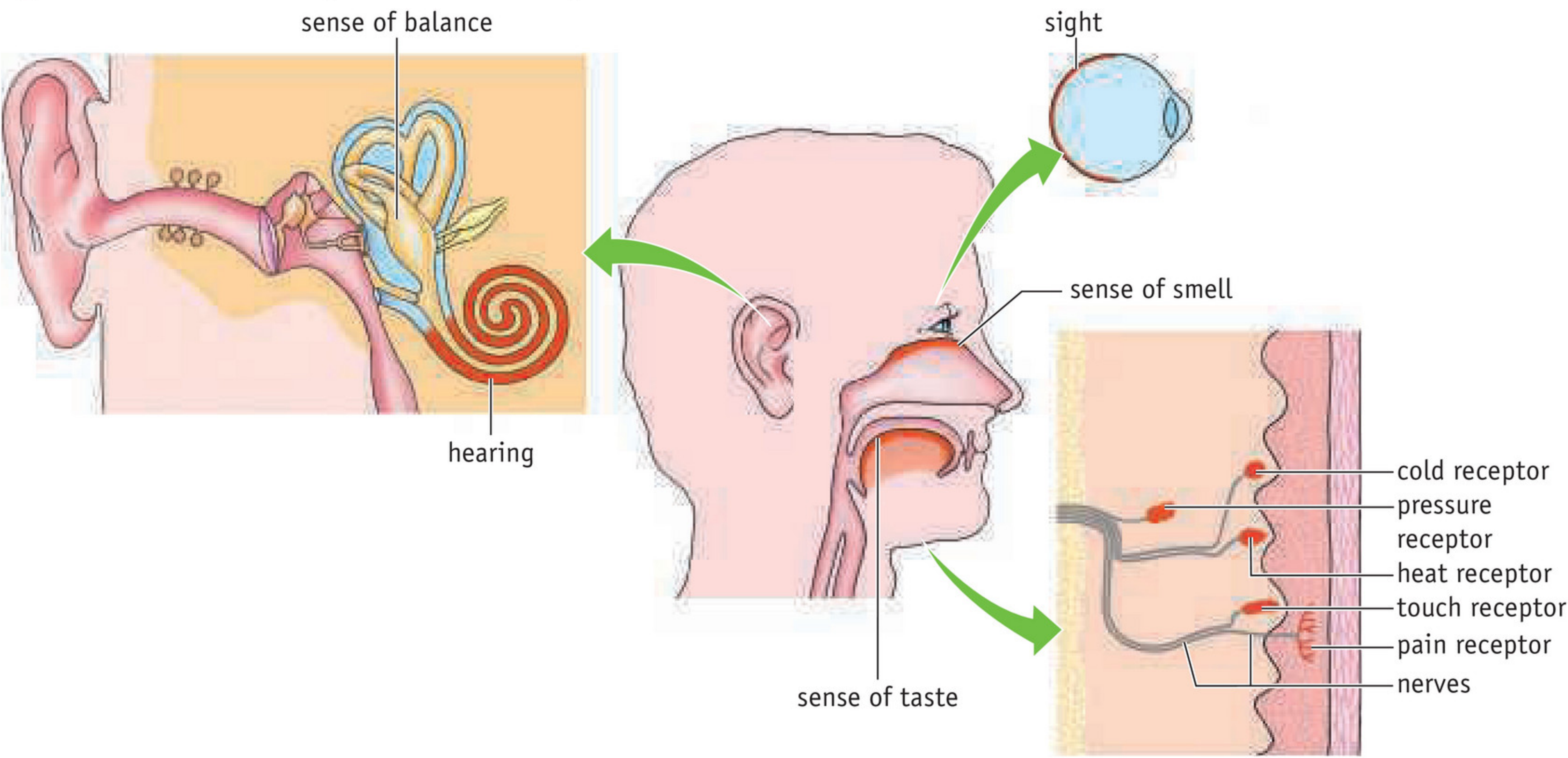
The sense organs have **sensory cells**. Sensory cells are connected to nerves that are then connected to the brain. When sensory cells receive stimuli, they generate **impulses**, a kind of electric signal. The nerves conduct the impulses to the brain.

SENSES

The most familiar senses are in your eyes and ears. But there are also senses in your nose, your tongue and your skin. Together, all your senses form the **sensory system**.

Figure 2 shows various senses. Your ears have two senses: the sense of balance and the sense of hearing. Each eye has a sense of sight, the nose has the sense of smell and the tongue has the sense of taste.

fig. 2 Location of some of your senses. Sensory cells can be found in the areas coloured red.



Your skin has four types of sensory receptor that give you your sense of touch: receptors for heat, cold, pressure and contact. **Heat receptors** respond when something that is warmer than the skin touches it. The **cold receptors** respond when your skin touches something that is colder than it is. **Pressure receptors** respond to pressure on the skin. **Touch receptors** respond to gentle contact on the skin. Your sense of touch let you perceive how objects feel, for instance whether they are smooth, rough, hard or soft. The sense of touch comes from in the actual touch receptors in the skin.

As well as the impulses that the senses receive, you can also perceive pain. **Pain receptors** let you perceive pain. These are the endings of certain nerves. Figure 2 shows a pain receptor in the skin. Pain receptors can be found at many places in the body, even in deeper-lying organs.

Each sense is sensitive to a different stimulus. Table 1 lists the senses, their locations and the stimuli they are sensitive to.

Table 1 Senses, their locations and stimuli.

Sensory organ	Location	Stimulus
Sight	in the eyes	mild
Sense of hearing	in the ears	sound
Sense of balance	in the ears	gravity
Sense of smell	in the nose	odour
Sense of taste	in the tongue	taste
Heat receptor	in the skin	heat
Cold receptor	in the skin	cold
Pressure receptor	in the skin	pressure
Sense of touch	in the skin	gentle contact

KNOWLEDGE

1

- a** An influence on an organism from its surroundings is *an impulse / a stimulus*.
- b** Where are electrical signals produced when sound is perceived?
- c** What is the name for these electrical signals?
- d** Younus has his eyes closed. Zoe puts something to eat in his mouth and asks him to say what he is tasting.
What part of his body is Younus using to perceive what he is eating?
- e** When he is tasting the food, *impulses / stimuli* are sent from his tongue to his brain via *nerves / senses*.

2

- a** What are pain receptors?
- b** Where in the body can pain receptors be found?

3

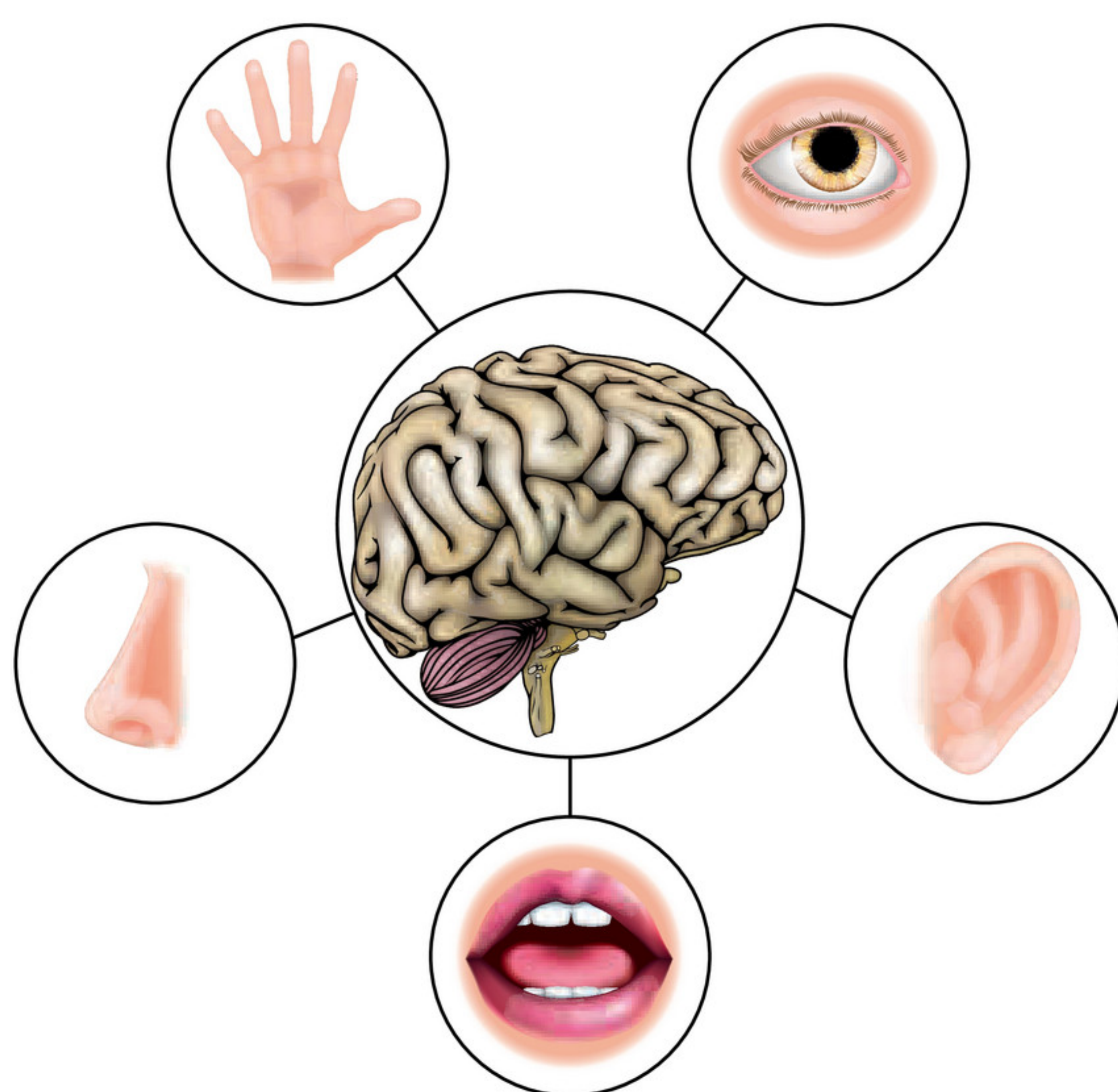
Connect each sense to the stimulus it is sensitive to.

- | | | |
|---------------------|-----------------------|--|
| A sight | ☐ | ☐ 1 pressure |
| B sense of hearing | ☐ | ☐ 2 sound |
| C sense of balance | ☐ | ☐ 3 scent/odour |
| D sense of smell | ☐ | ☐ 4 cold |
| E sense of taste | ☐ | ☐ 5 light |
| F heat receptor | ☐ | ☐ 6 gentle contact |
| G cold receptor | ☐ | ☐ 7 taste |
| H pressure receptor | ☐ | ☐ 8 heat |
| I sense of touch | ☐ | ☐ 9 gravity |

4

**Summary**

Write a summary of the basics in figure 3. Name all senses and their stimuli and complete the text.

fig. 3

A sense is:.....

Sensory cells in sensory organs receive..... This results in..... from the sensory cells.

Impulses are transmitted from the sensory organs via..... to the.....

The brain processes the impulses that come from the senses.

INSIGHT

5

You are cycling to school. On the way, you come across a traffic light that turns red. Put the steps for this perception in the correct sequence.

- The traffic light turns red.
- Your brain observes that the traffic light is red.
- Your eye receives the light stimuli.
- Nerves conduct the impulses to the brain.
- Sensory cells in your eye turn the light stimuli into impulses.

6

Roger is on holiday by the sea.

- a** Which sense or which senses does he use to perceive a cool summer breeze on his skin?
- b** On a hot day, Roger is lying in the sun on the beach.
Why is it important that you can perceive the heat of your surroundings and objects around you through heat receptors in your skin?

7

Your food has not only a particular taste and temperature but also a certain texture: it can be soft, juicy, rubbery, sticky, crispy or smooth, for instance. Most people like chocolate, not just because of the taste but also because the texture of chocolate changes in your mouth as the chocolate melts.

Which senses in your tongue do you use to perceive that the chocolate in your mouth is melting?

8

A cavity in the dentine of your molar can expose the tooth's nerve. This can give you a nasty toothache.

Are there pain receptors in your teeth? Explain your answer.

+ 9

In diabetics, nerves deeper in the body can get damaged. This is called nerve damage or neuropathy. Symptoms of nerve damage are numbness or tingling sensations.

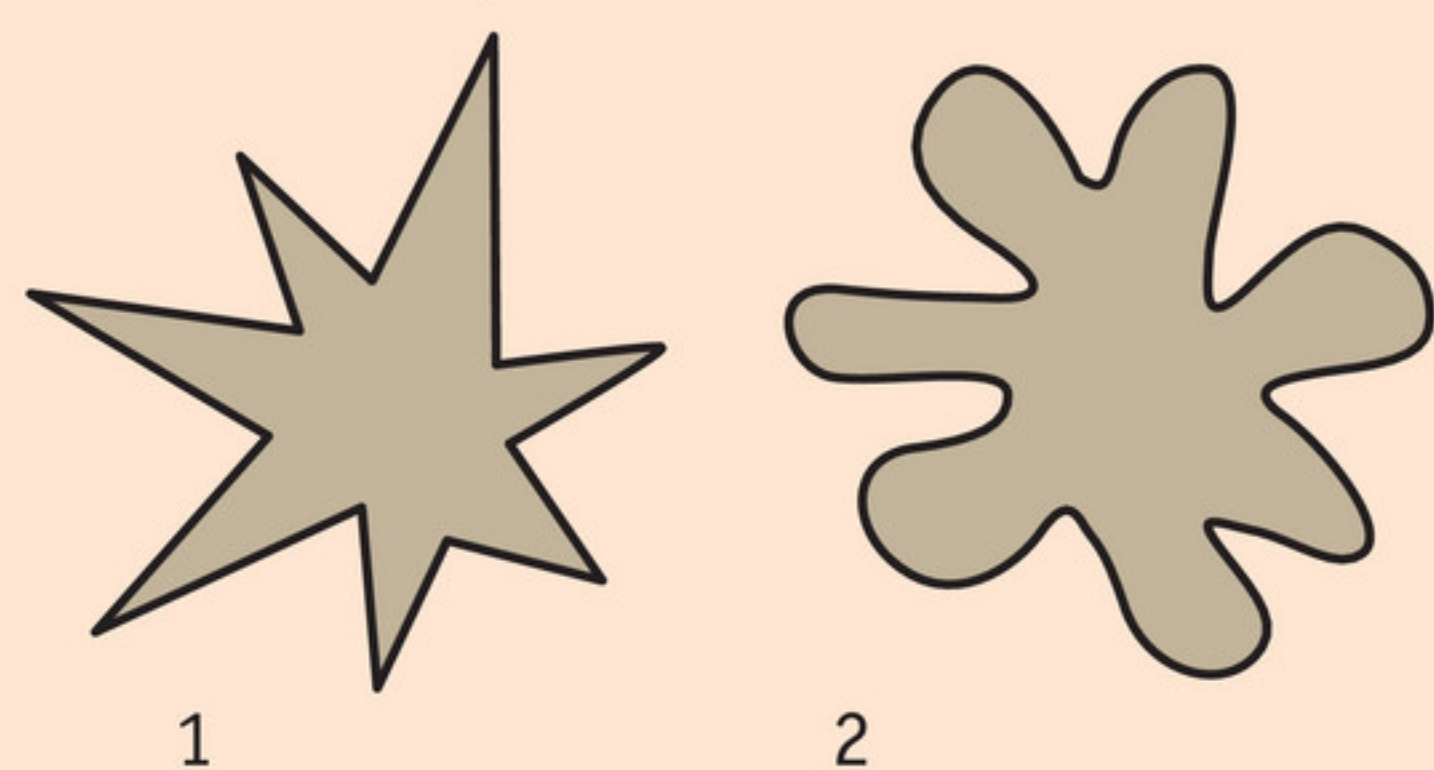
- a** Explain how these symptoms can occur.
- b** Leprosy is a disease that is caused by bacteria. The bacteria affect the nerves in the skin, which leads to numbness.
Explain how numbness occurs in a leprosy patient.
- c** Pain is the body's signal to indicate that something is wrong. Being able to feel pain is important for staying healthy. In leprosy patients, the nerves of the pain receptors get affected.
Explain how a leprosy infection can quickly spread because of that.

HOW IT FITS TOGETHER the living world

SYNAESTHESIA

When Robyn reads numbers printed in black, she perceives colours at the same time. To her, the number 5 is ochre. The composer and pianist Franz Liszt saw colours in music and would sometimes ask his orchestra to play a certain piece of music to make it a bit bluer. He apparently assumed that everyone saw the same thing. Scientists call this phenomenon synaesthesia, which literally means ‘sensing together’. In people with synaesthesia, some senses are connected much more strongly than in other people. As a result, the impulses in the brain are processed in a different way than in most of us. This characteristic of the brain occurs in just a few people and is sometimes hereditary.

fig. 4 An example of synaesthesia: the bouba/kiki effect.



10

Read the text on ‘Synaesthesia’.

The ability for impulses to combine different senses is extremely well-developed in people with synaesthesia. But it also happens in people who do not have synaesthesia. You are going to do a Practical activity that shows this.

Have a look at the shapes in figure 4.

- a** Which shape would you call ‘bouba’ and which is ‘kiki’?
- b** Ask nine other people the same question. Write down the result and your conclusion.
- c** Which senses do the stimuli that are combined in your brain during this experiment come from? Explain your answer.

 Go to the *Flash cards* and the *Test yourself* section.

2 Touch, smell, taste

LEARNING OBJECTIVES

- 5.2.3 You can describe the structure and functions of the skin.
- 5.2.4 You can say how you smell different scents.
- 5.2.5 You can say how you taste different flavours.
- Practical activities 2, 3 and 4

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES			
	5.2.3	5.2.4	5.2.5	5.1.2*
Remembering	1, 2abcd	3a	4ab	
Understanding	2e, 5	3bc, 5	4c, 5	
Using	6abcd, 7, 10cd	8a		
Analysing	6e, 10ab	8bc, 9	8c	10a

* You can find this learning objective in another Basics section.

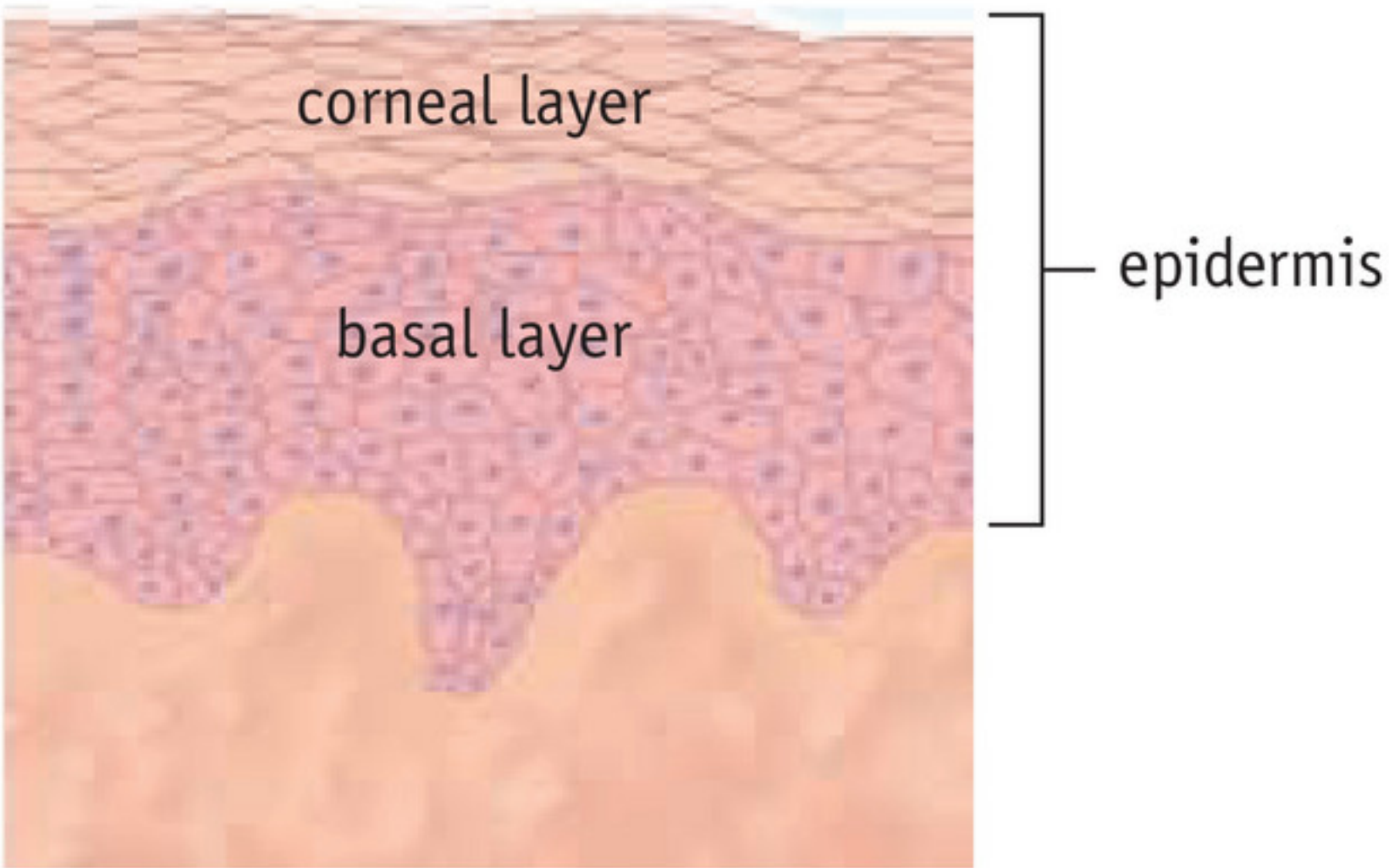
Your skin is your largest organ. It contains several senses that tell you how things feel. You smell and taste with senses in your nose and tongue.

EPIDERMIS

The skin is made up of two parts: the epidermis and the dermis. The **epidermis** has two layers: the corneal layer and the basal layer (see figure 1). The **corneal layer** consists of the remains of dead cells. The corneal layer protects your body against damage, dehydration and pathogens (bacteria). The corneal layer is continually wearing off on the outside.

The **basal layer** consists of living cells. The bottom layer of cells in the basal layer are continuously dividing. This keeps creating more new basal layer cells. The top layer of basal cells move outwards until they are on the outside and become cornified. This means that they produce a lot of keratin. Keratin can be found in nails and in hair too. Once the cells have become cornified, they will die off.

fig. 1 The epidermis.



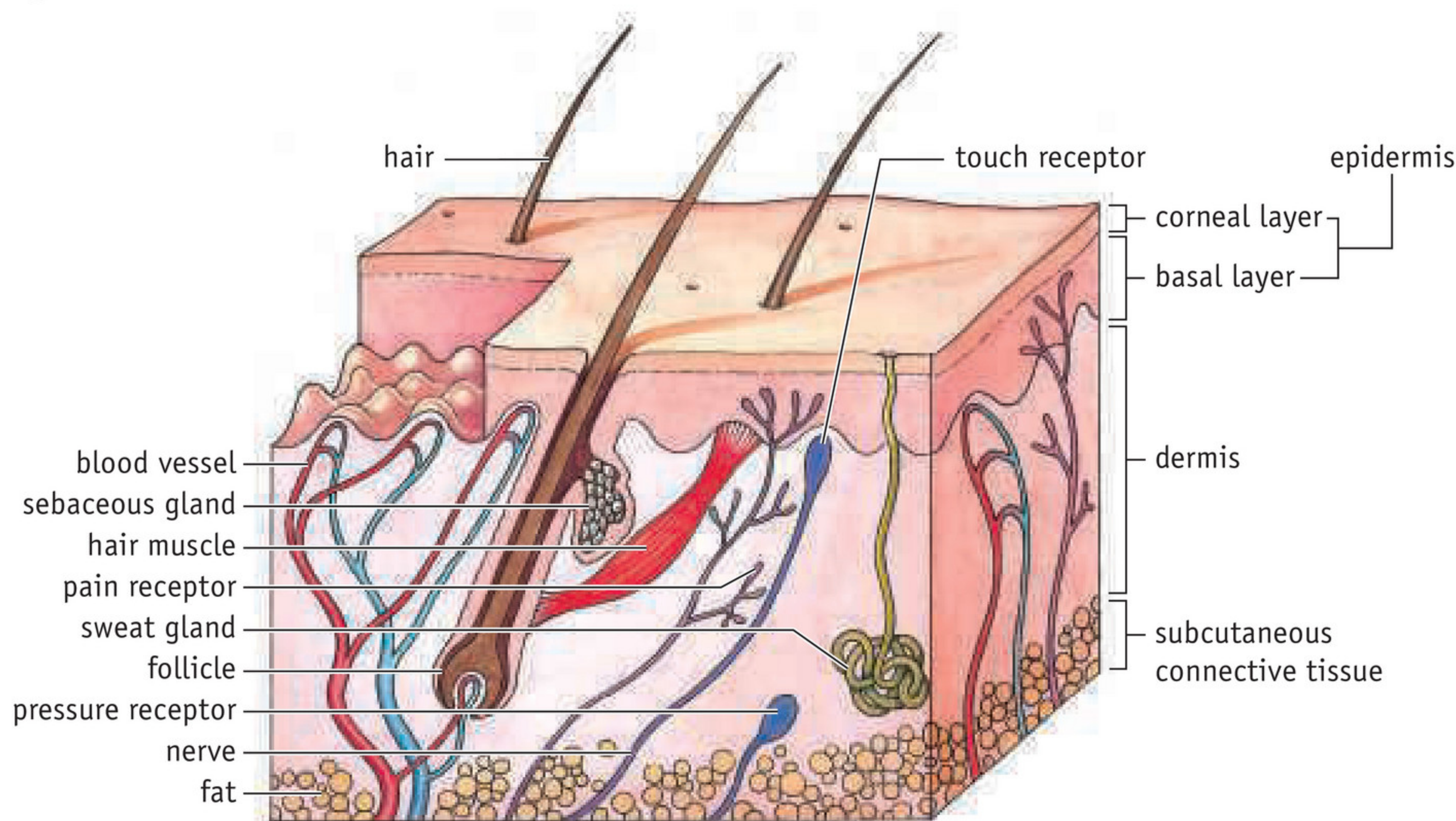
DERMIS

The **dermis** has the heat receptors, cold receptors, pressure receptors and touch receptors (see figure 2). The sensory cells for the sense of touch can be found in touch receptors just beneath the basal layer, as can the heat and cold receptors. The receptor cells for the sense of pressure are found deeper in the skin. The dermis also contains nerves with pain receptors, hair muscles, blood vessels and sweat glands.

The **sweat glands** produce sweat, particularly when you are hot. Evaporation of sweat lets your body cool down. This how the skin plays a role in regulating body temperature. A **follicle** is a part of the basal layer that protrudes into the dermis. A hair grows from the bottom of the follicle out through the epidermis. The follicles contain **sebaceous glands** that produce sebum. Sebum is a fatty substance that keeps the hair and the corneal layer flexible.

The **subcutaneous connective tissue** lies beneath the skin. Fat is stored in this tissue, where it can be used as a food reserve. Fat creates an insulating layer that helps prevent loss of heat from the body.

fig. 2 The skin and the subcutaneous connective tissue.



BURNS

A **burn** is damage to your skin caused by heat, a chemical substance or electricity. The skin is damaged where it was burned and so that area is no longer protected. Bacteria can enter the body more easily, causing an infection. You also lose more moisture and heat.

Burns can be severe or less serious, depending on the location, the size and the depth of the wound. The body can restore the epidermis, but if the dermis gets damaged it does not grow back. Figure 3 tells you what to do in the event of a burn.

fig. 3

First aid for burns

- 1** Cool the burn for ten minutes with lukewarm, gently running tap water. Remove clothing, jewellery (and babies' nappies) as quickly as possible. Cooling reduces the pain and removes heat from the wound. This makes sure a burn does not get worse.
- 2** Avoid making the whole body cool down too much: only cool the wound.
- 3** Cover an open wound with plastic or Clingfilm, sterile dressing or a clean cloth. Covering the wound makes sure it stays clean. It also reduces the pain.
- 4** Do not apply anything to the burn. Creams, ointments, balms, toothpaste or other products can make the wound worse. Do not use iodine compounds (such as Betadine) either.
- 5** Contact a doctor if there are large blisters or an open wound or for burns caused by chemicals or electricity.

Source: Brandwondenzorg Nederland.

SMELL AND TASTE

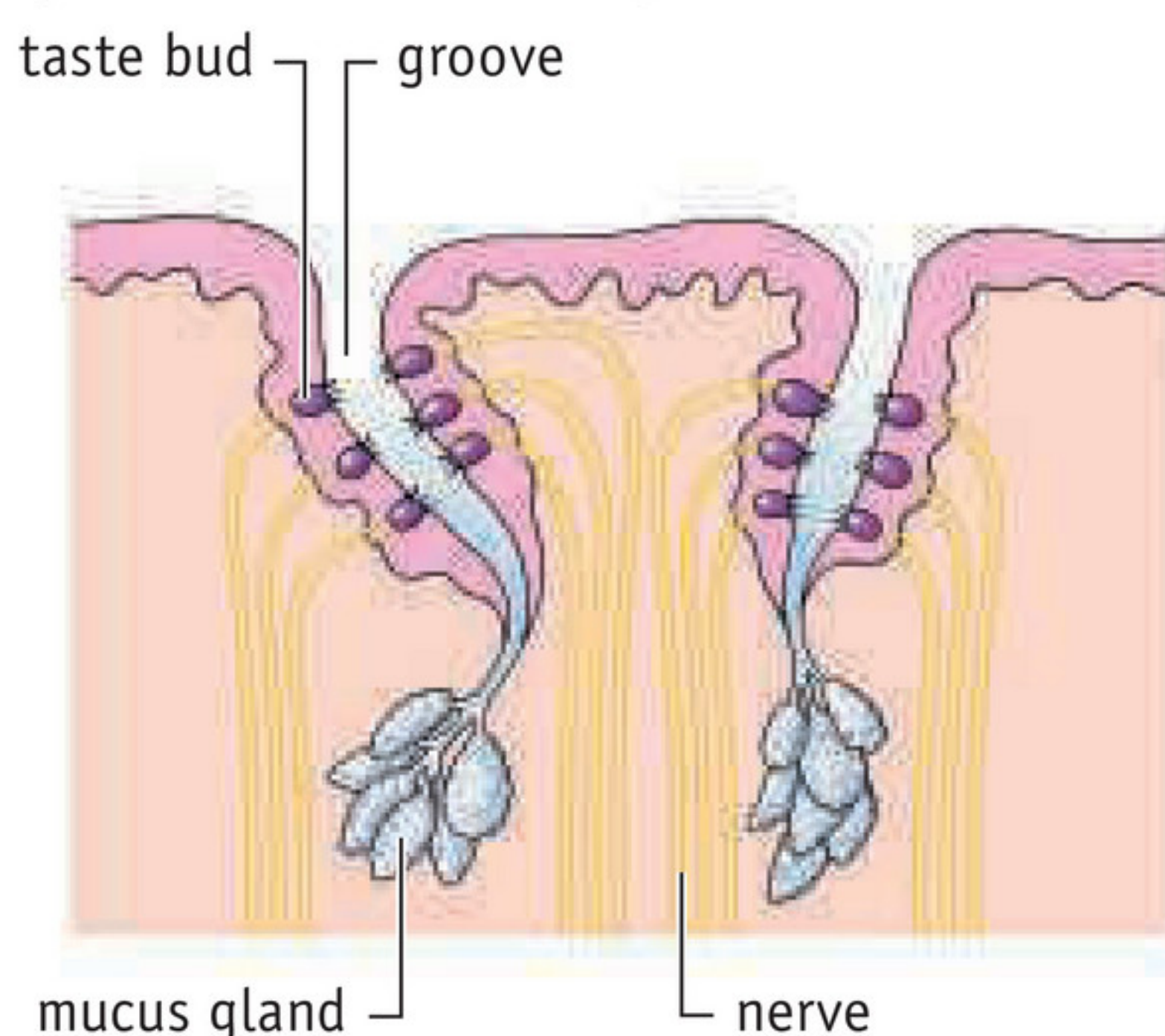
The sense of smell – the **olfactory system** – is located in the roof of the nasal cavity. The olfactory cells are located in the nasal mucous membrane. These are stimulated when various molecules go past them and they then send impulses to the brain.

Most smells involve multiple substances. There are many types of olfactory cells in the nasal cavity. Each type is sensitive to a particular substance. This creates a pattern of impulses in the olfactory nerve. Your brain translates these impulses and you smell the scent.

The **taste receptors** are on the surface of the tongue. The surface of your tongue has a lot of very small grooves. The sides of these grooves have **taste buds** (see figure 4). The taste buds contain the sensory cells for taste.

The sensory cells for taste in your tongue can distinguish between five types of tastes: sweet, salty, sour, bitter and umami (savoury). There are separate taste buds for each of these five tastes. You perceive all other tastes with your sense of smell too.

fig. 4 Taste buds in the tongue.



KNOWLEDGE

1

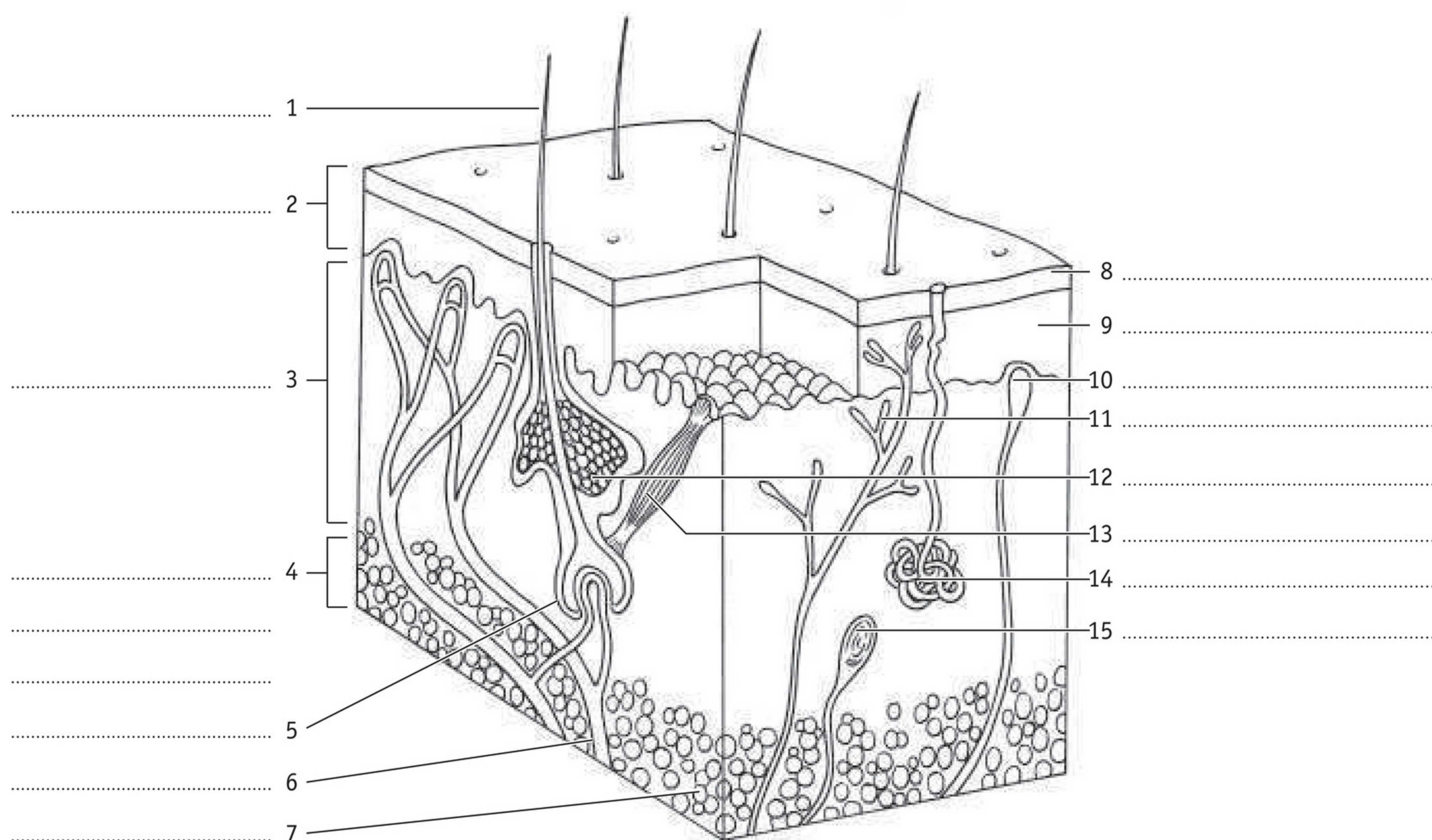
Figure 5 shows a cross-section of the skin.



a Write down the names of the numbered parts. Use figure 2.

b Colour in the various parts in the drawing. Use a different colour for each part.

fig. 5 A cross-section of the skin.



2

Your skin is the first line of defence against influences from your surroundings. The skin protects your body in a variety of ways.

- a** Wounds can close up quickly because the top layer of your skin is rapidly renewed.
Flakes fall from the *corneal layer* / *basal layer*.
- b** You sweat more when it is warm.

..... of sweat lets your body cool down. This how the skin

plays a part in regulating
- c** Feeling pain protects your body against damage.
Pain receptors are located in *the dermis* / *the epidermis* / *both layers of the skin*.
- d** Your skin also makes sure that you do not dehydrate.

....., which is secreted by the,

keeps your skin flexible.
- e** A burn means that the skin is damaged.
Explain why you should cover a burn with Clingfilm, a sterile dressing or a clean cloth.

3

- a** Where are the sensory cells of the sense of smell located?
- b** Perfumes are made up of different substances.
What allows you to smell the different substances in a perfume?
- c** How do you perceive the scent of a perfume?

4

- a** Where are the taste buds for the sense of taste?
- b** You can taste various flavours with your sense of taste.
Which flavours do you have taste buds for?
- c** You taste all other flavours because your

registers as well.

5



Summary

Make a summary of this basic course material by completing the texts.

The structure and functions of the skin:

- The epidermis consists of:

-; function:
-; function:

- The dermis has
- Sebum:
- Sweat:
- Subcutaneous connective tissue:
- A burn is

Smell, how the sense of smell works:

.....

.....

.....

Taste, how the sense of taste works:

.....

.....

.....

INSIGHT

6

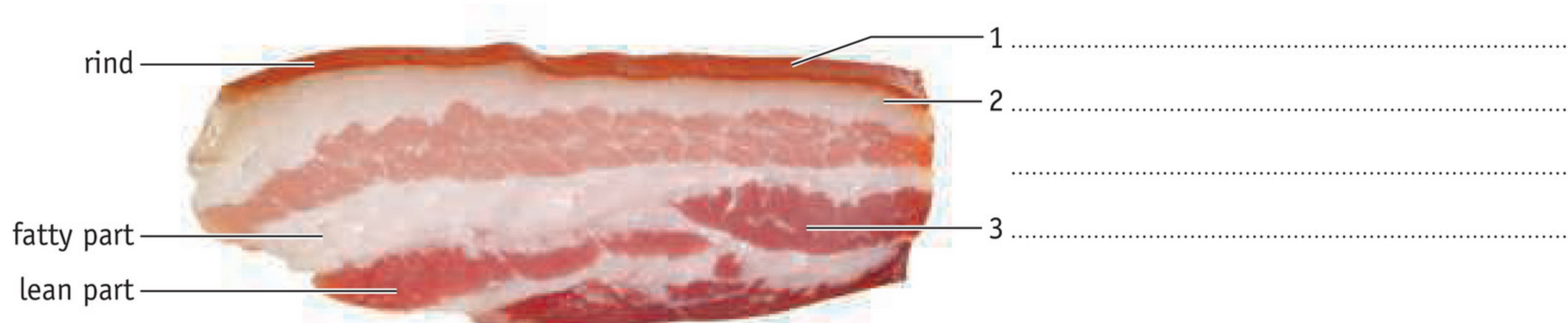
- Joshua gets a snake tattoo. The drawing is made in (not on) his skin with ink and it will remain visible his entire life.
Is the ink applied to the epidermis or to the dermis? Explain your answer.
- Nina has tattoos drawn on her hands with henna. Henna tattoos disappear after a few weeks.
The pigments of the henna go into the *dermis* / *epidermis*.
- Additives are sometimes added to henna which can cause allergic reactions such as contact eczema. Contact eczema can be recognized by itchy, red skin with small bumps, vesicles and flaking. The vesicles often pop open.
Which function can the skin no longer properly perform? Explain your answer.
- Why is someone with a thicker skin less likely to be cold?
- What happens when the hair muscles contract? Have a look at figure 2 if you need to.

7

Figure 6 shows a photo of a part of the skin of a pig. The butcher sells this as bacon. It consists of a rind, a fatty part and a lean part.

Fill in the names of the parts. Choose between: *subcutaneous connective tissue* – *dermis and epidermis* – *muscle tissue*.

fig. 6 Part of the skin of a pig.



8

If you want to smell something properly, you inhale sharply and strongly.

- a** Why do you do that?
- b** You are able to breathe through your nose (nasal respiration) or through your mouth (oral respiration).
Explain why nasal respiration lets you respond more alertly to situations in your surroundings that may be dangerous for you.
- c** When you have a cold, the mucous membrane in your nose is swollen and your nose is blocked.
Explain why you cannot taste things so well when you have a cold.

+ 9

Read the text 'A sensitive nose' in figure 7.

- a** Explain why the size of the part of the brain for smelling in different animal species must be determined in relation to the total brain volume and body weight.
- b** Humans have around five million olfactory cells. A bloodhound (see figure 7) has around three hundred million.
Explain why the part of the brain intended for recognizing smells is much larger in a bloodhound than in humans.

fig. 7

A sensitive nose

In animals that can smell well, the part of the brain that receives impulses from the olfactory cells is larger than in animals that can smell less well. To be able to compare the sense of smell of different animal species, researchers determined the size of that part of the brain with respect to the total brain volume and the bodyweight of for various animal species. By then comparing different animal species, it is possible to get a good impression of how strong or weak the sense of smell is in that species.



HOW IT FITS TOGETHER profession

BURNS UNIT NURSE

Burn victims in the Netherlands usually end up in one of the three burns units. These are the only places they can get the intensive care they need. The patients are looked after by burns unit nurses. These nurses have specialized in burns after taking the nursing course. To be able to take this course, you must already be working in a burns unit. As a burns unit nurse, you learn how to treat and take care of burns and how to treat these patients carefully. Most victims remember the incident well and burns leave serious scars. That is why it takes a long time to recover, both physically and mentally.

fig. 8 Taking care of a burn.



10

Read the text about a 'Burns unit nurse'.

There are three types of burns. In first-degree burns, the skin is not damaged but is usually reddened. In second-degree burns, the epidermis is damaged down to the dermis. The skin may be damaged and blisters can appear. In third-degree burns, both the epidermis and dermis are badly damaged right down to the subcutaneous connective tissue.

- a** Explain why someone with a third-degree burn does not feel pain.
- b** You can get first-degree burns if you sit in the sun for too long.
Why do you not have to cover up first-degree burns?
- c** Why should you only cool the wound and not the rest of the body when you get a burn?
- d** Riyadh was in a car accident in which the airbags in his car were inflated. There was nothing wrong with Riyadh at first. Later it became clear that a substance from the airbags had caused burns on his forearms. Riyadh did not think it was serious enough to see a doctor.
Was Riyadh right? Explain your answer.

 Go to the *Flash cards* and the *Test yourself* section.

3 Hearing and sight

LEARNING OBJECTIVES

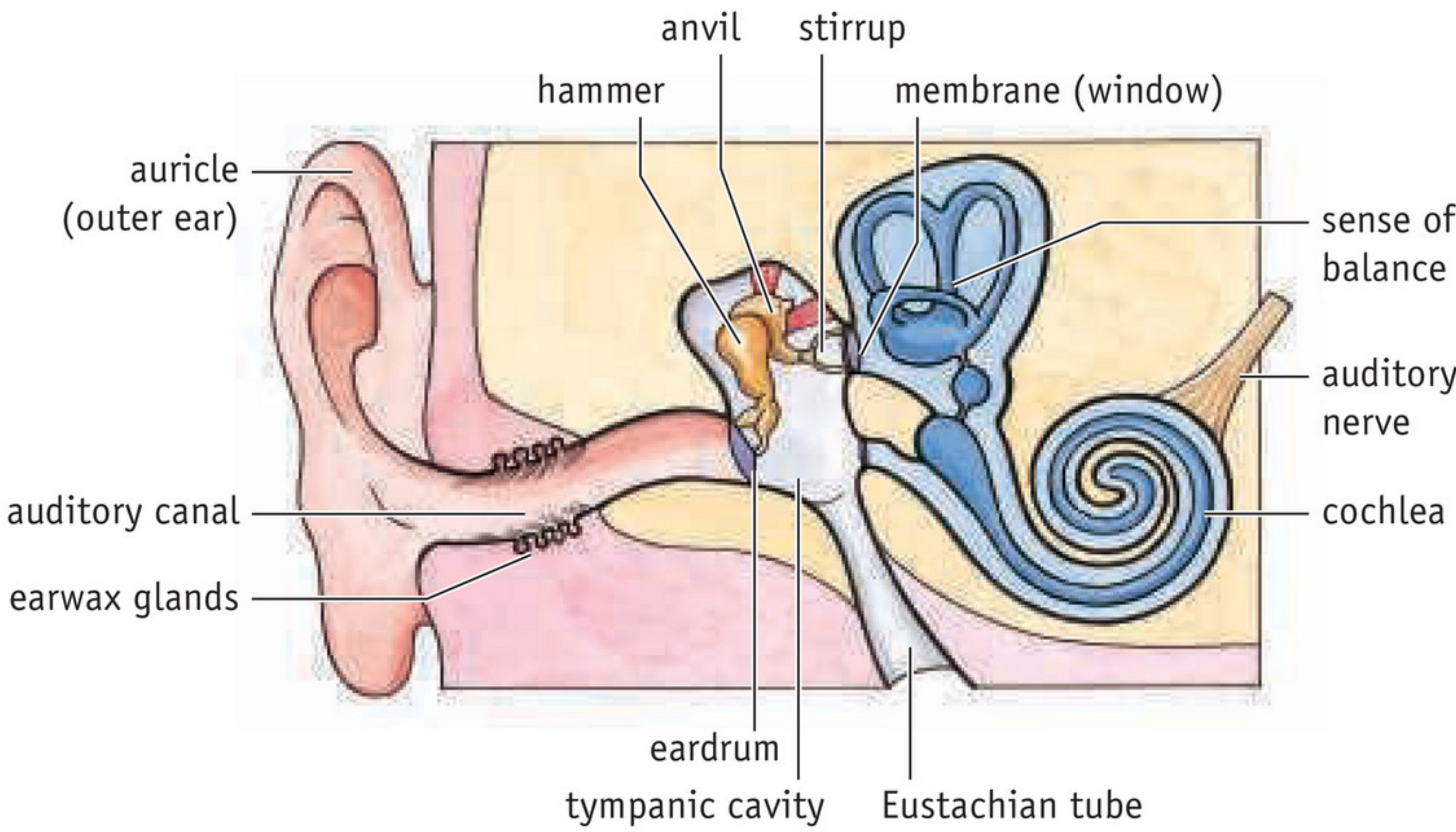
- 5.3.6 You can list the parts of the ear and their functions.
- 5.3.7 You can describe the structure and function of the eye.
- Practical activity 5

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES	
	5.3.6	5.3.7
Remembering	1, 2abc	3, 4c
Understanding	2d, 6	4abd, 5, 6
Using	7a, 9c	8a
Analysing	7bcd, 9ab	8b, 10

THE STRUCTURE OF THE EAR

Each ear contains sensory organs for hearing and balance (see figure 1). Your **auditory receptors** let you perceive sounds. Sound are vibrations in the air. The **auricle** (outer ear) receives these vibrations. The sounds go through the **auditory canal** and reach the **eardrum**, which is made to vibrate. The auditory canal has small **earwax glands** that produce earwax. The earwax keeps the eardrum flexible to make sure it vibrates properly.

fig. 1 The structure of the ear.



Behind the eardrum is the **tympanic cavity**. The three **auditory ossicles** (small bones) can be found there: the hammer, anvil and stirrup. The stirrup is connected to the oval window: a thin membrane. On the other side of the oval window is the **cochlea**. It consists of three chambers that are rolled up into a spiral. The chambers are filled with fluid.

The eardrum makes the ossicles vibrate. The ossicles pass the vibrations on to the window in the cochlea. The liquid in the chambers of the cochlea starts to vibrate too. The middle chamber of the three contains sensory cells that are stimulated by the vibrations of the liquid. The sensory cells then produce impulses. The **auditory nerve** passes impulses to the brain.

The **Eustachian tube** connects the tympanic cavity to the pharynx. The walls of the tube are usually pressed together so that the tube is closed. When you swallow or yawn, the tube opens. Air can then move from the tympanic cavity to the pharynx (back of the throat) and vice versa. This helps the air pressure on both sides of the eardrum stay the same, which is needed if the eardrum is to vibrate properly.

THE STRUCTURE OF THE EYES

Figure 2 shows the parts around an eye and outside it. The eyebrows make sure that sweat and other liquids do not get into your eyes. The eyelashes protect the eyes against dirt and bright light.

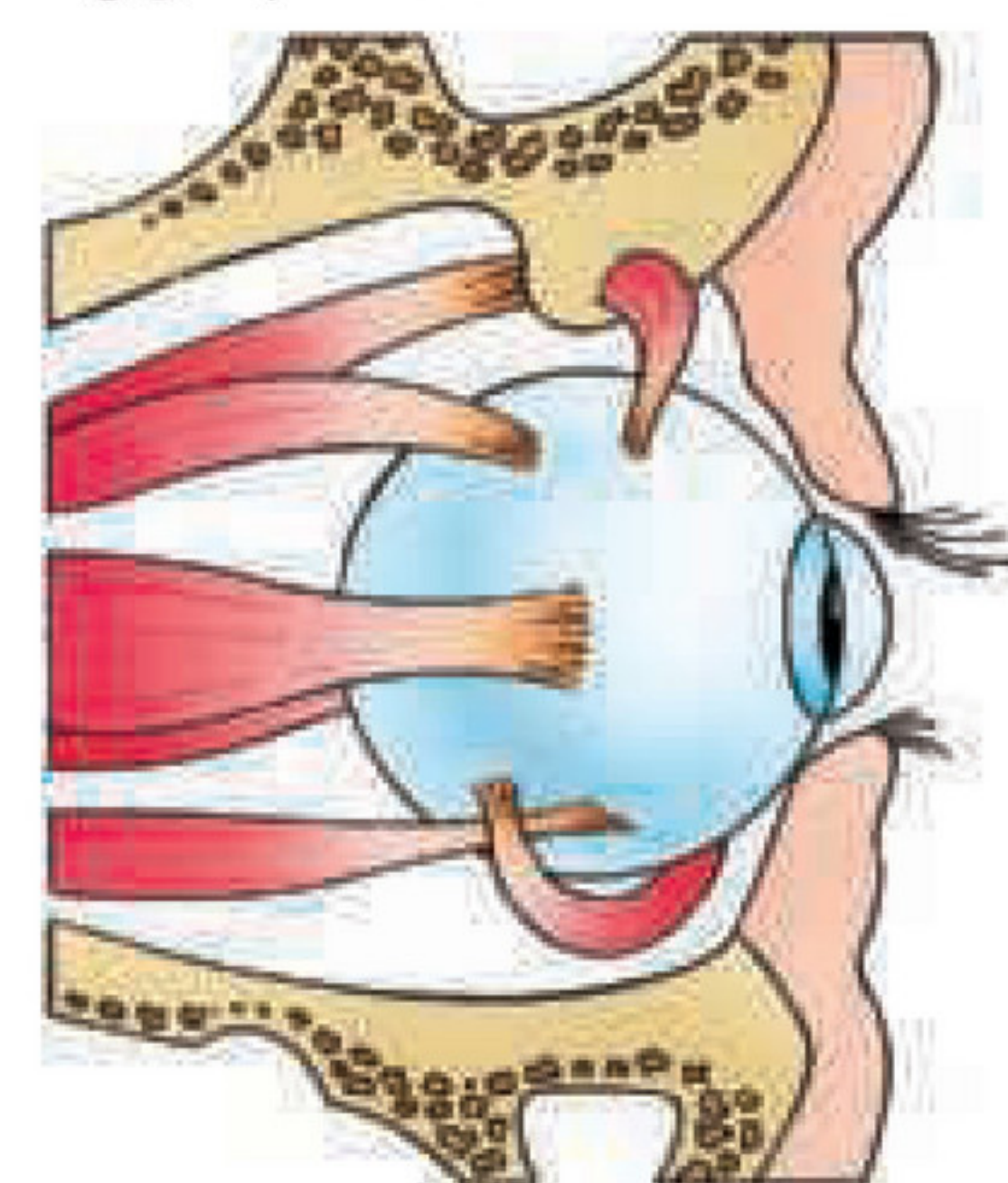
The white of the eye is called the **sclera**. The **eye muscles** are attached to the sclera (see figure 3). The eye muscles can turn the eyes in any desired direction.

The coloured part of the eye is called the **iris**. The iris has an opening called the **pupil**. The pupil lets light into the eye. The iris and the pupil are covered by the transparent **cornea**.

fig. 2 An eye.



fig.3 Eye muscles.

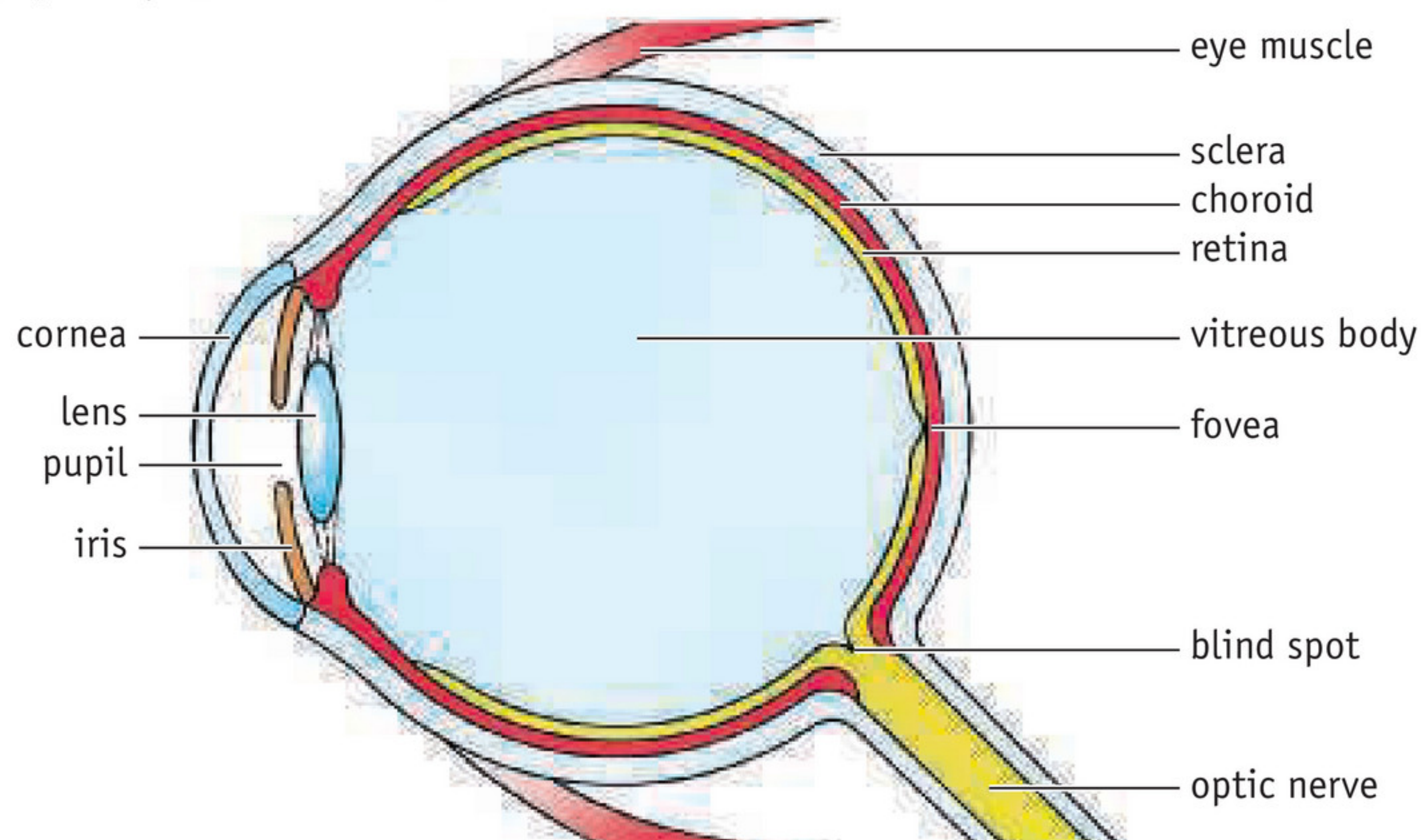


Underneath the skin above the eyes are the **tear glands** (lachrymal glands). These produce tears. Blinking makes the eyelids spread the tears across the eyes. The tears protect the eyes against dehydration and clean them. The tears drain to the nasal cavity through the tear ducts.

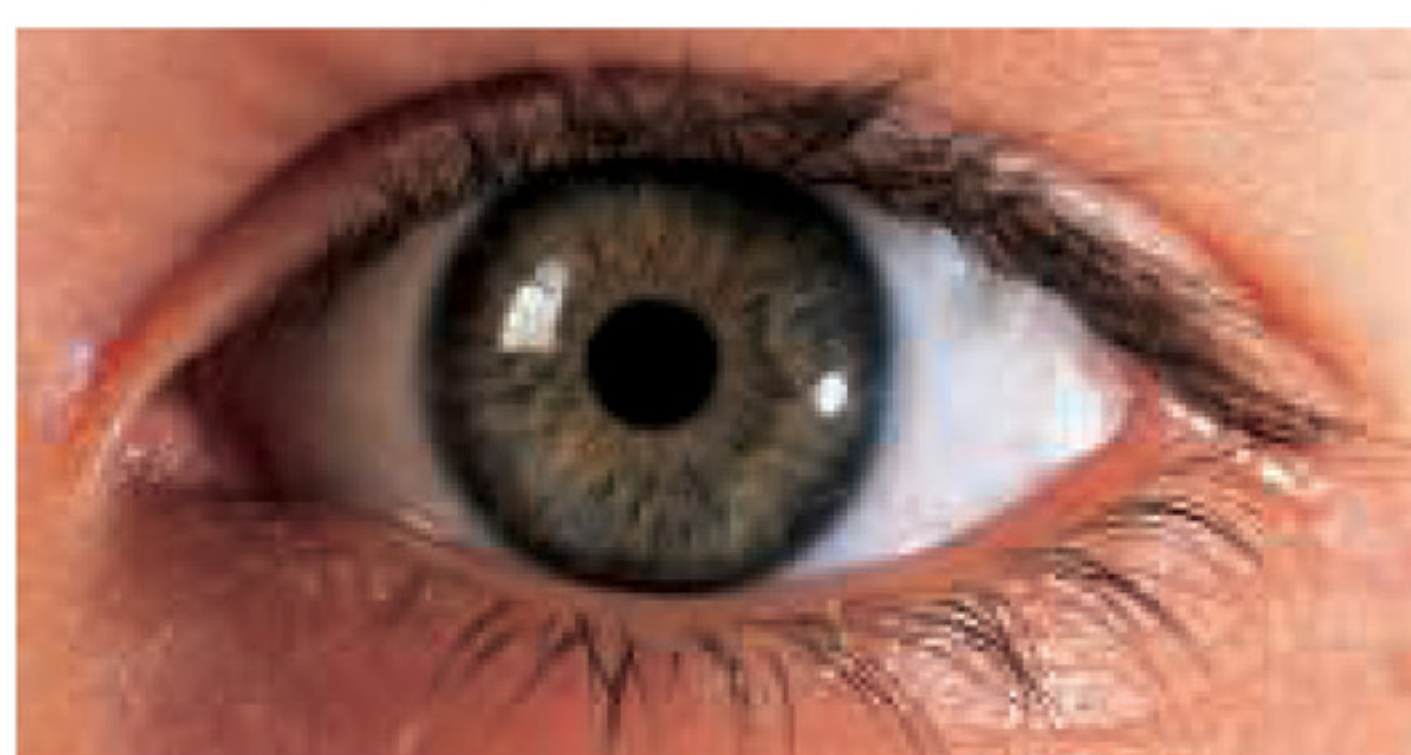
Figure 4 shows a cross-section through an eye. Most of the eyeball is filled with a jelly-like mass, the **vitreous body**. Behind the iris and the pupil is the **lens**. The lens makes sure that you can see sharply.

The wall of an eye consists of three layers: the sclera, the choroid and the retina. The **choroid** contains a lot of blood vessels. It handles the nutrition for the eye. The **retina** contains the sensory cells. The sensory cells then produce impulses when light falls onto them. The **optic nerve** transmits the impulses to the brain.

In the retina, directly opposite the pupil, is the **fovea**. The sensory cells in the fovea let you see most sharply. If you are looking at something, you rotate your eyes so that you are basically looking at it with the fovea. The part of the retina where the optic nerve leaves the eye is called the **blind spot**. There are no sensory cells on the blind spot.

fig. 4 An eye (cross-section).**THE PUPILLARY REFLEX**

Light enters your eye through the pupil. The pupil gets larger and smaller depending on the amount of light. This is referred to as the **pupillary reflex**. The pupillary reflex regulates the amount of light that falls onto the retina. When there is a lot of light, the pupil gets smaller (see figure 5.1). Less light can then enter your eye. When the light is dim, the pupil gets bigger (see figure 5.2). A large pupil lets a lot of light through. This lets you see even when it is almost dark.

fig. 5 The pupillary reflex.

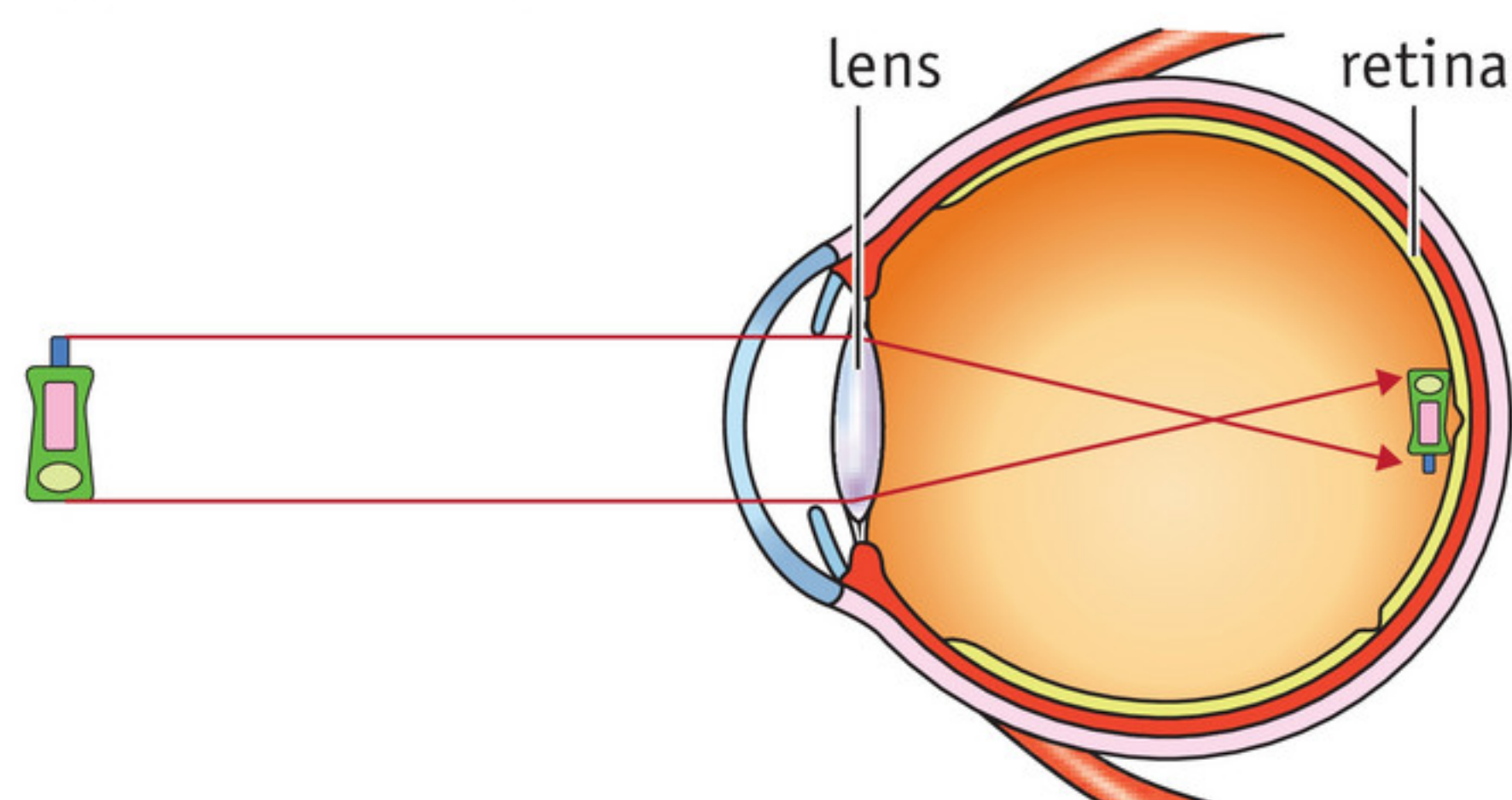
1 in bright light



2 in dim light

HOW THE EYE WORKS

Light that enters your eyes first goes through the lens. The lens can be made rounder or flatter. This lets the lens make sure that the rays of light are focused exactly onto the retina's fovea (see figure 6). You will then be able to see a clear image. The lens also flips the image upside down, but that is 'corrected' by your brain.

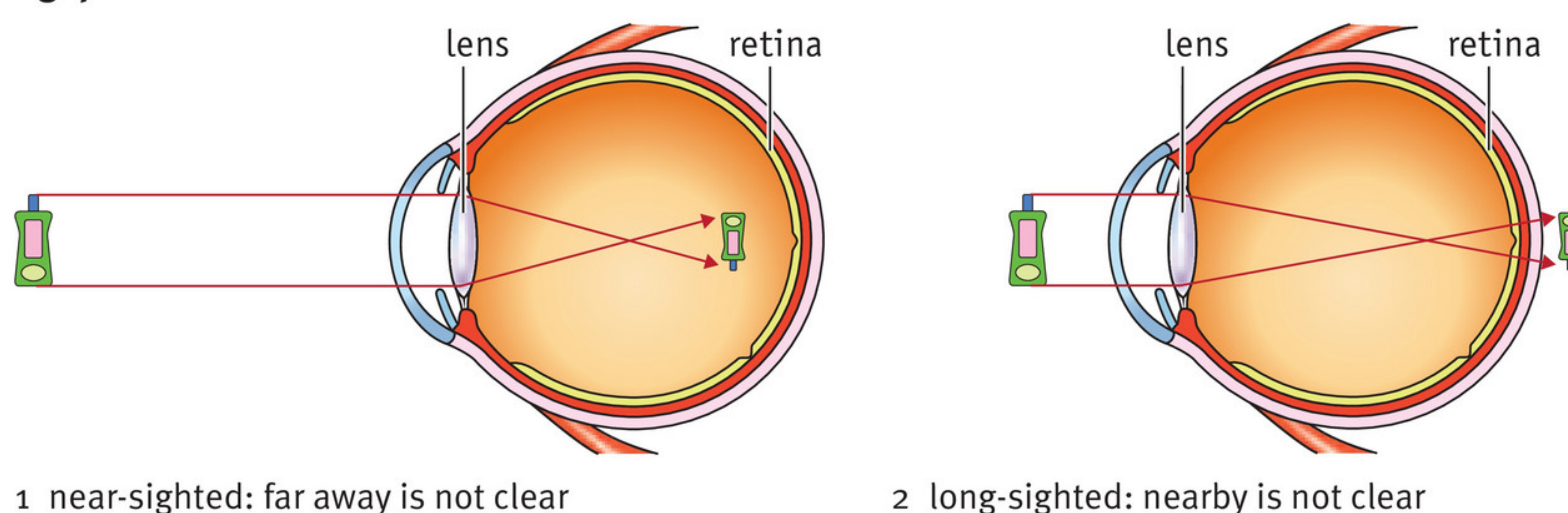
fig. 6 How the eye works.

In some people, the eye's lens does not work properly or the eyeball is too long or too short. The image (the light) cannot then be focused accurately on the retina. That person does not see clearly.

Someone who is **near-sighted** can only clearly see things **near** to them. When they look into the distance, the image ends up in front of the retina (see figure 7.1). The lens of the eye is too convex (rounded) – or the eyeball is too long. Near-sightedness can be corrected with glasses or contact lenses with **concave lenses**. Wearing these, the image is again exactly on the retina.

Someone who is **long-sighted** can see everything that is a **long** way off clearly. When they look at something nearby, though, the image ends up focused beyond the retina (see figure 7.2). In a long-sighted person, the lens of the eye is too flat (or the eyeball is too short). Glasses with **convex lenses** ensure that the image is focused precisely at the retina.

fig. 7



1 near-sighted: far away is not clear

2 long-sighted: nearby is not clear

KNOWLEDGE

1

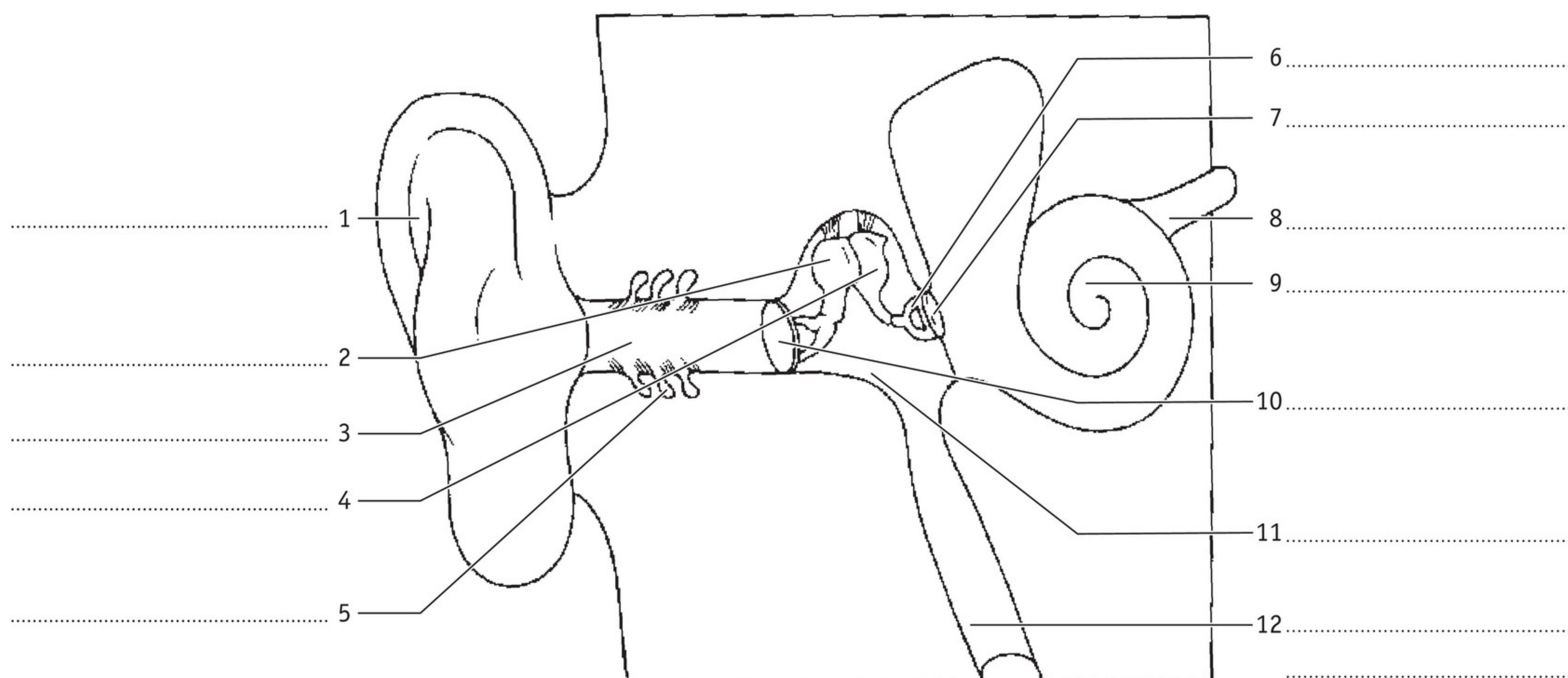
Figure 8 is a schematic drawing of the parts of the ear.

a Write down the names of the numbered parts. Use figure 1.

b Colour in the various parts in the drawing. Use a different colour for each part.



fig. 8 Schematic drawing of the ear.



2

- a** What keeps the eardrum flexible?
- b** Where in an ear are stimuli (the vibrations) converted into impulses?
- c** The Eustachian tube connects the tympanic cavity to the
- d** What path do the sound, the vibrations and the impulses take when you hear a sound? Put the sentences in the correct sequence.

..... The ossicles pass the vibrations on to the oval window in the cochlea.

..... The auditory nerve passes impulses to the brain.

..... The liquid in the chambers of the cochlea starts to vibrate too.

1 Sound is captured by your outer ear.

..... The eardrum makes the ossicles vibrate.

..... The eardrum starts vibrating.

..... Impulses are produced in the sensory cells in the cochlea.

..... The sounds reach the eardrum via the auditory canal.

..... The sensory cells in the middle chamber are stimulated by the vibrations of the liquid.

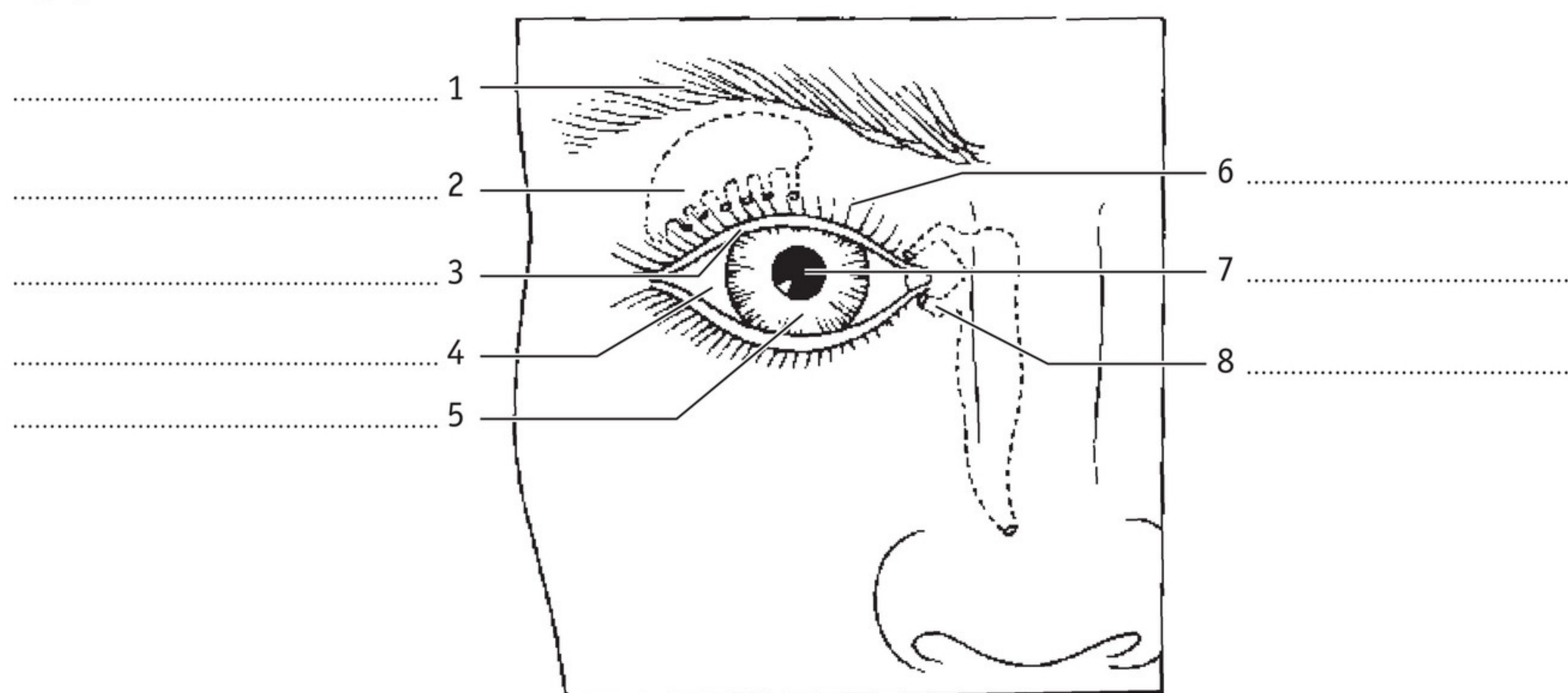
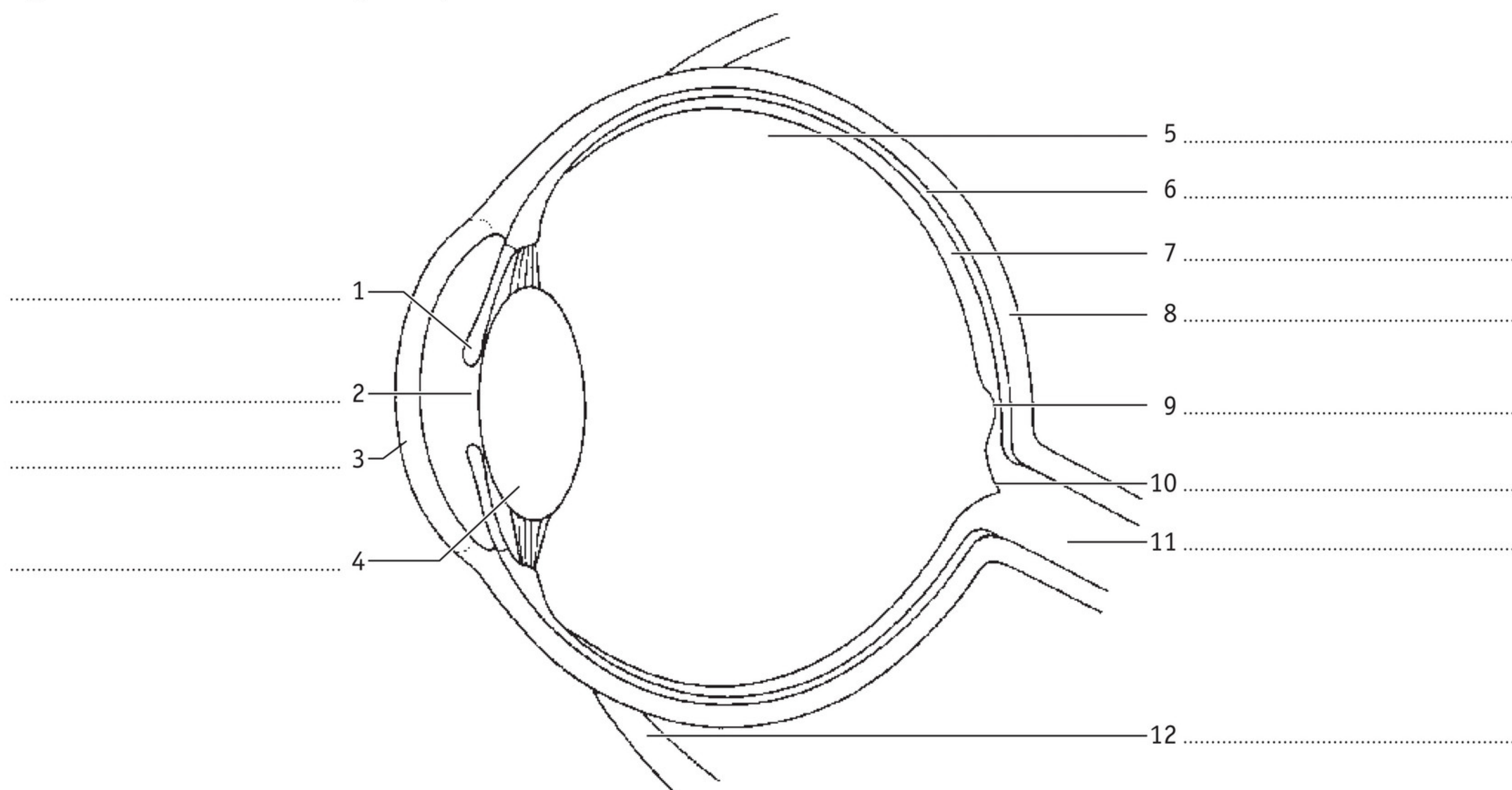
3



Figures 9 and 10 show schematic drawings of the eye.

- a** Write down the names of the numbered parts.
- b** Colour in the various parts in the drawings. Use a different colour for each part.
- c** Write down the name of each part next to each description of the eye.

1 the white part	.....
2 these parts can turn the eyes in any desired direction	.....
3 the coloured part	.....
4 the opening in the iris	.....
5 the transparent part at the front	.....
6 the jelly-like mass inside the eye	.....
7 the part that makes sure that your vision focused	.....
8 the part that provides nutrients for much of the eye	.....
9 this part contains the eye's sensory cells	.....
10 this part conducts impulses from the eye to the brain	.....
11 the spot in the middle of the retina	.....
12 the point on the retina where the optic nerve leaves the eye	.....

fig. 9 Part of a face.**fig. 10** A cross-section through an eye.

4

a The sensory cells in Fabio's left eye are damaged.

What part of Fabio's eye is damaged?

*sclera / cornea / retina / choroid***b** What path does the light take through the eye? Put the parts in the correct sequence. End with the retina.

..... vitreous body

..... cornea

..... lens

5 retina

..... pupil

c The image of an object on the retina is *inverted* / *upright* and *enlarged* / *reduced*.

- d** How can you see reality upright and at the correct size?
- ☐ A The cerebrum interprets the image on your retina the right way up.
 - ☐ B The eye lens produces an image that is upright and the correct size.
 - ☐ C The sensory cells in the retina turn the image into impulses.
 - ☐ D The image on your retina is upright and the correct size.

5

- Susie can no longer read the small print on a jar of jam.
- a** Is Susie near-sighted or long-sighted? Explain your answer.
- b** To be able to read the small print on a jar of jam, Susie needs glasses with *convex* / *concave* lenses.

6



Summary

Make a summary of this basic course material.

- Describe the path of the vibrations and impulses when you hear something.
- Describe the path of the light and impulses when you see something.
- Describe the pupillary reflex.
- What is near-sightedness, what causes it and how can it be fixed?
- What is far-sightedness, what causes it and how can it be fixed?

To hear, the path of the sound (vibration) and impulses:

.....

.....

.....

.....

To see, the path of light and impulses:

.....

.....

Pupillary reflex:

-
-

Near-sighted:

.....

.....

.....

Long-sighted:

.....

.....

.....

INSIGHT

7

An infection of the throat can result in an ear infection.

- a Explain how.
- b The air pressure is less at high altitudes. You notice this in your ears if you change altitude too quickly, for example in a ski lift.
If you go up a mountain quickly in a ski lift, the air pressure in the tympanic cavity becomes *higher* / *lower* than the pressure of the outside air.
- c If you go up a mountain quickly in a ski lift, the difference in air pressure will make the eardrum bulge.
The eardrum will then bulge *inwards* / *outwards*.
- d If the eardrum bulges outwards because the air pressure is different on each side, you may hear a ringing sound or get a clogged feeling in the ears. This can be fixed by swallowing or yawning. That opens the Eustachian tube.
Explain what happens then.

8

Figure 11 shows a cat and a mouse. Study the figure like this:

- Hold this book out at eye level with your arms straight.
 - Close your left eye.
 - Stare at the cat with your right eye. You can then see the mouse in the corner of your eye.
 - Keep looking at the cat while you move the book slowly towards your head.
- a What happens to the mouse as you move the book towards your head?
 - b When you can no longer see the mouse, the image of the mouse is falling on the *blind spot* / *fovea* in the retina. When you are looking at the cat, its image is on the *blind spot* / *fovea* in the retina.

fig. 11



+ 9

Read the text on 'The cocktail party effect' in figure 12.

- a Explain how you can tell what direction a sound is coming from.
- b People who can only hear with one ear have trouble following a conversation in a room with a lot of background noise. Explain why.
- c Bats use echolocation to navigate and to catch prey. They locate objects or prey by sending out sound and listening to the echoes. Explain why bats often have large outer ears.

fig. 12

The cocktail party effect

Our ears can work out the direction sounds come from. Because of the different positions of the ears, sound from one side (a bit to one side) will reach one ear sooner than the other. 'Hearing the direction' is important when you are in an environment where a lot of conversations are happening at once and you only want to follow one of those conversations. This feature of being able to separate a conversation from the background noise is known as the 'cocktail party effect'.

HOW IT FITS TOGETHER the living world

NEAR-SIGHTED BECAUSE OF TABLETS AND SMARTPHONES

Near-sightedness is the fastest-growing eye abnormality globally and is rapidly becoming the number one cause of blindness later in life. Near-sightedness can be hereditary, but your risk of getting it increases if as a child you often have a screen in front of you and so you are looking at things close to you. Your eyes have to strain to focus and start to adjust. They become more oval (longer). As a result, rays of light are no longer focused on the retina but in front of it, and your vision becomes more and more blurred when you look into the distance.

To prevent near-sightedness, it is best to look at something else after twenty minutes of looking at a screen. And children should go outdoors for at least two hours a day. Outdoors there is a lot of light, which makes the body produce a substance (dopamine) that inhibits the deformation of your eyeballs. In adults, the eyeballs are already fully grown and looking at a screen has little effect on the shape of the eyeballs.

fig. 13



10

Read the text 'Near-sightedness because of tablets and smartphones'.

- a** Looking a lot at things nearby in dark conditions – such as reading in the dark – is very bad for your eyes.
Explain why, using the text.
- b** One in three people who wear glasses of strength minus 6 or above become severely visually impaired later in life. Some people who are near-sighted get 'bare spots' in the retina. These spots do not have sensory cells.
Explain why a near-sighted person with the bare spots in the retina cannot see well.
- c** Other near-sighted people become visually impaired due to glaucoma. In this condition, the optic nerve becomes pinched off. This damages the optic nerve.
Explain why someone with glaucoma will have more and more trouble seeing.

 Go to the *Flash cards* and the *Test yourself* section.

4 The nervous system

LEARNING OBJECTIVES

5.4.8 You can describe the structure and functions of the nervous system.

► Practical activity 6

5.4.9 You can describe the structure of nerve cells and nerves.

5.4.10 You can describe a reflex arc.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES			
	5.4.8	5.4.9	5.4.10	5.1.2*
Remembering	1ab	2		
Understanding	1cde, 4	4	3, 4	
Using		5ac	7ab, 9ab	9c
Analysing		5b, 6	7c, 8, 9d	

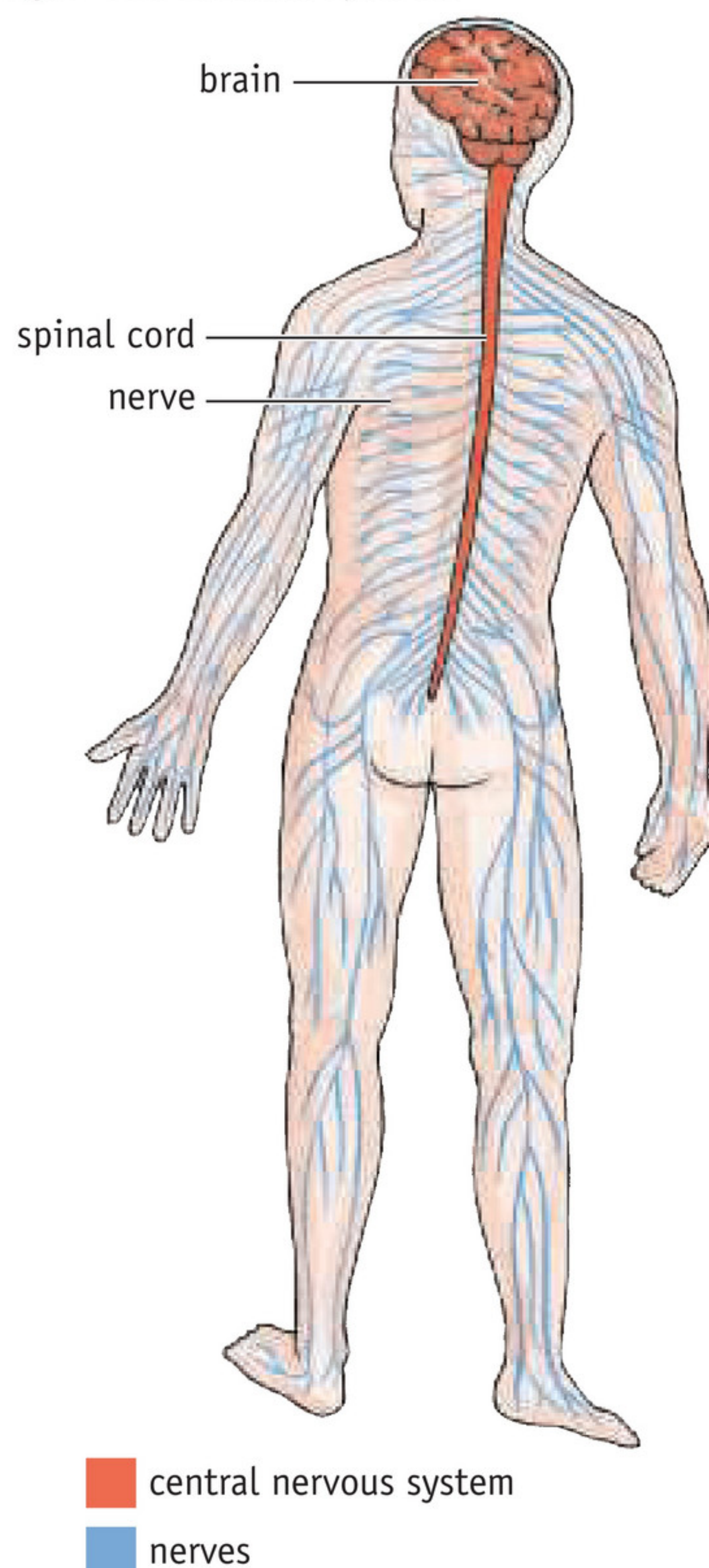
* You can find this learning objective in another Basics section.

Sensory cells transmit impulses to nerves. The nerves conduct the impulses to the brain. The brain sends impulses to muscles and glands.

THE STRUCTURE OF THE NERVOUS SYSTEM

Figure 1 shows a diagram of the human nervous system. The nervous system is made up of the **central nervous system** and the nerves. The central nervous system consists of the brain and the **spinal cord**. The nerves connect the central nervous system to all parts of the body.

fig. 1 The nervous system.



HOW THE NERVOUS SYSTEM WORKS

Figure 2 shows an example of how the nervous system works. The sensory cells of the sense of vision and the sense of smell generate impulses that are transmitted to the brain by the nerves. The brain processes the impulses, which make the girl aware of the chocolates.

When you become aware of the things that you are perceiving, you can also respond consciously. In a voluntary response like this, impulses are produced in your brain. In Figure 2, impulses are transmitted by nerves from the brain to the salivary glands and to the arm muscles. The salivary glands respond to the impulses by producing saliva. This makes the girl's mouth water. The arm muscles respond to the impulses by contracting. This lets the girl pick up a chocolate and move it to her mouth.

The nervous system processes the impulses that come from the sensory organs and it controls the muscles and glands. A **gland** is an organ that produces certain substances, such as the sweat glands, sebaceous glands and salivary glands.

fig. 2 How the nervous system works.

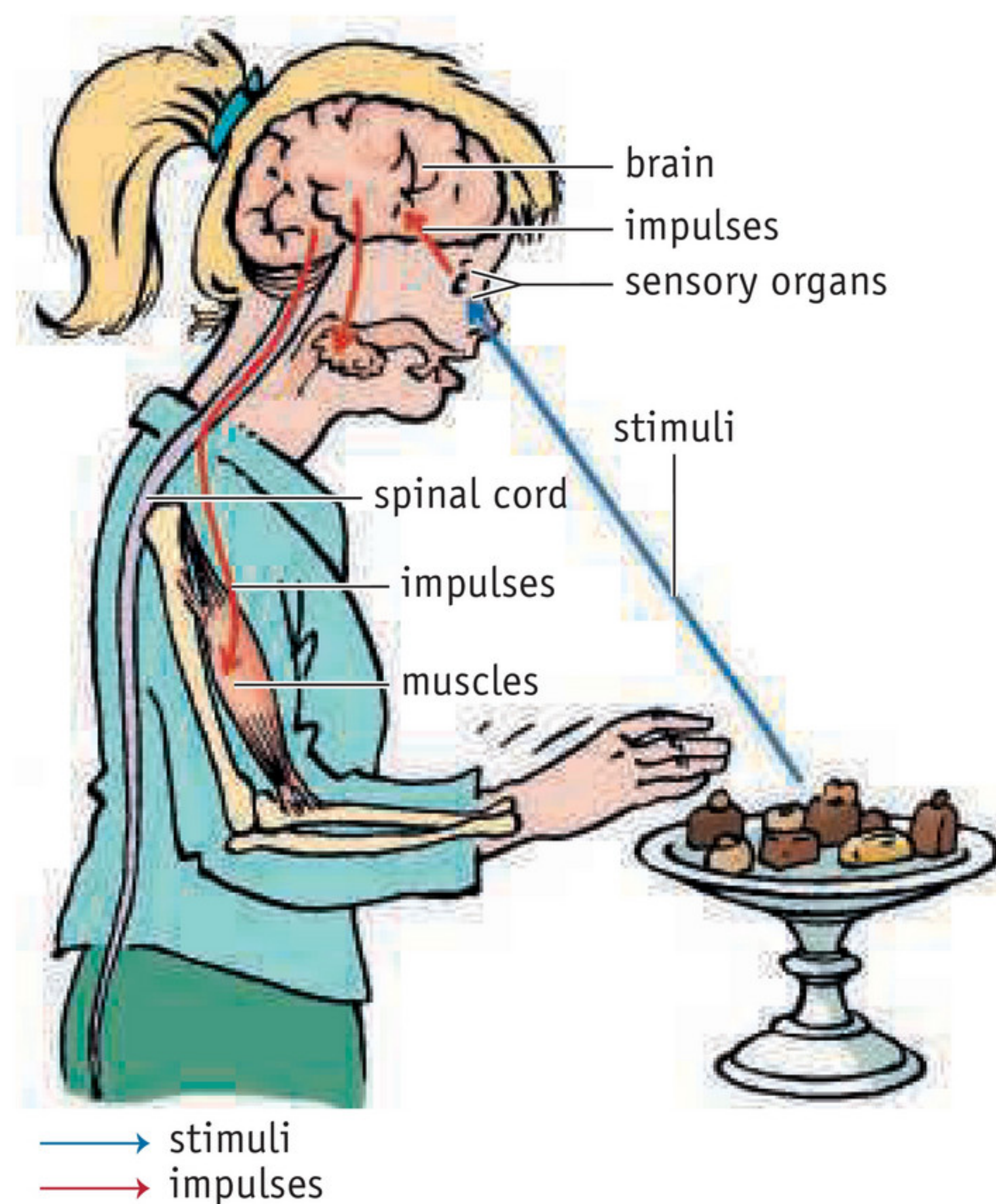
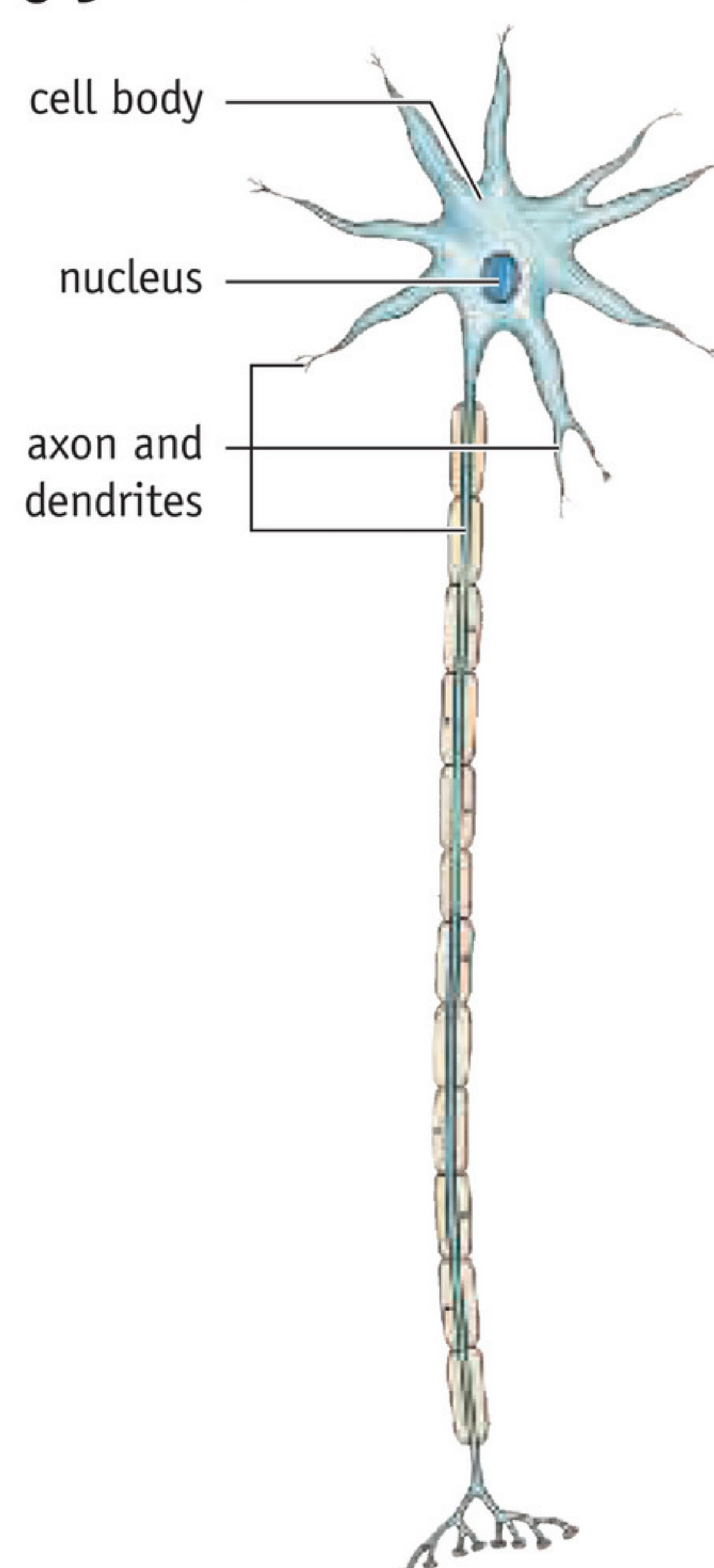


fig. 3 Structure of a nerve cell.



NERVE CELLS

The nervous system contains millions of **nerve cells**. Each nerve cell consists of a cell body and its protrusions that are called axons or dendrites (see figure 3).

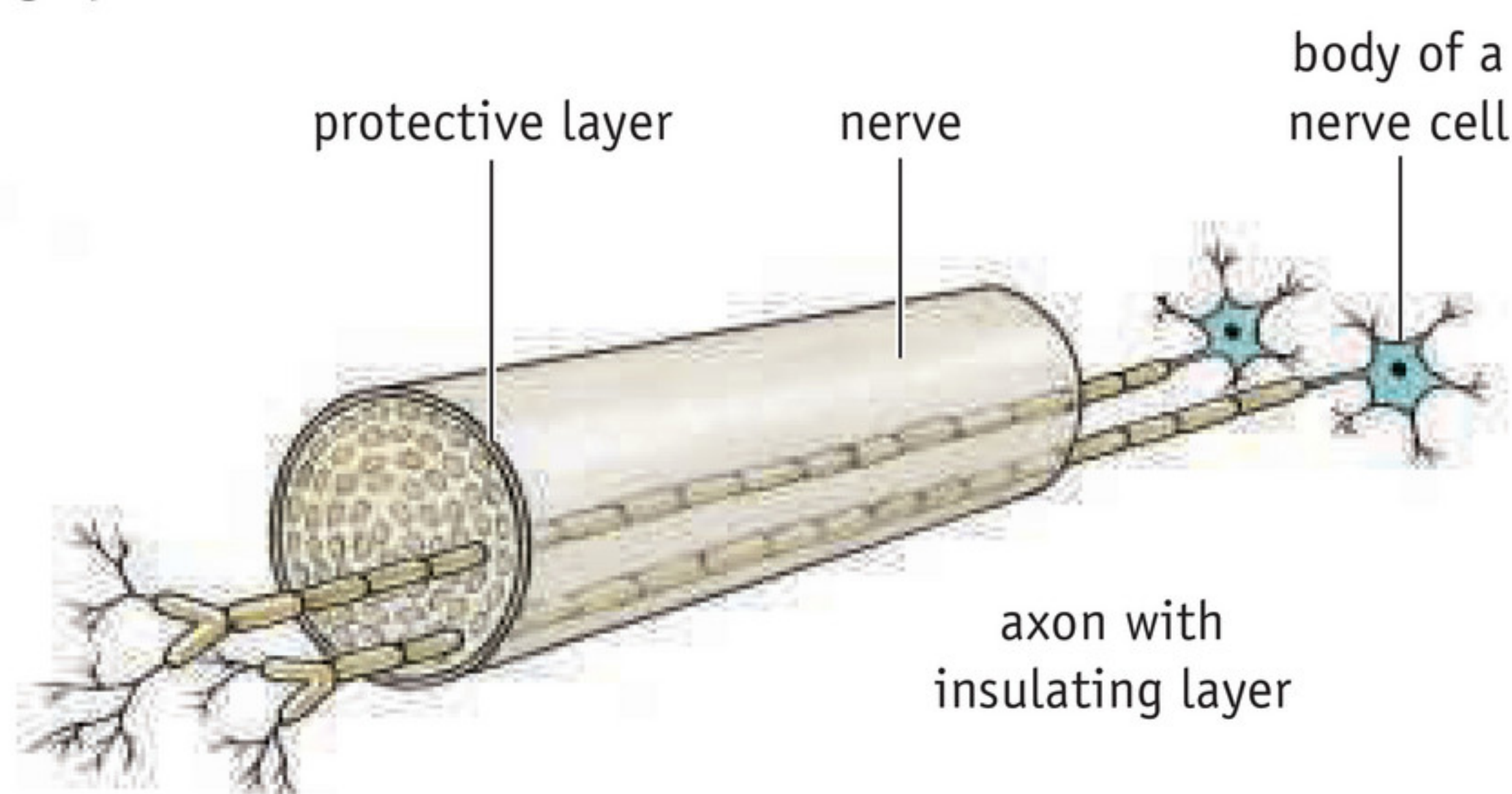
The **cell body** of a nerve cell is the part that contains the nucleus. The cell bodies of nerve cells are in or near the central nervous system.

The **axons** conduct the impulses. There are axons that conduct impulses to the cell body and axons that pass impulses away from the cell body. Axons can also pass the impulses to other cells or nerve cells. Axons can be very long.

NERVES

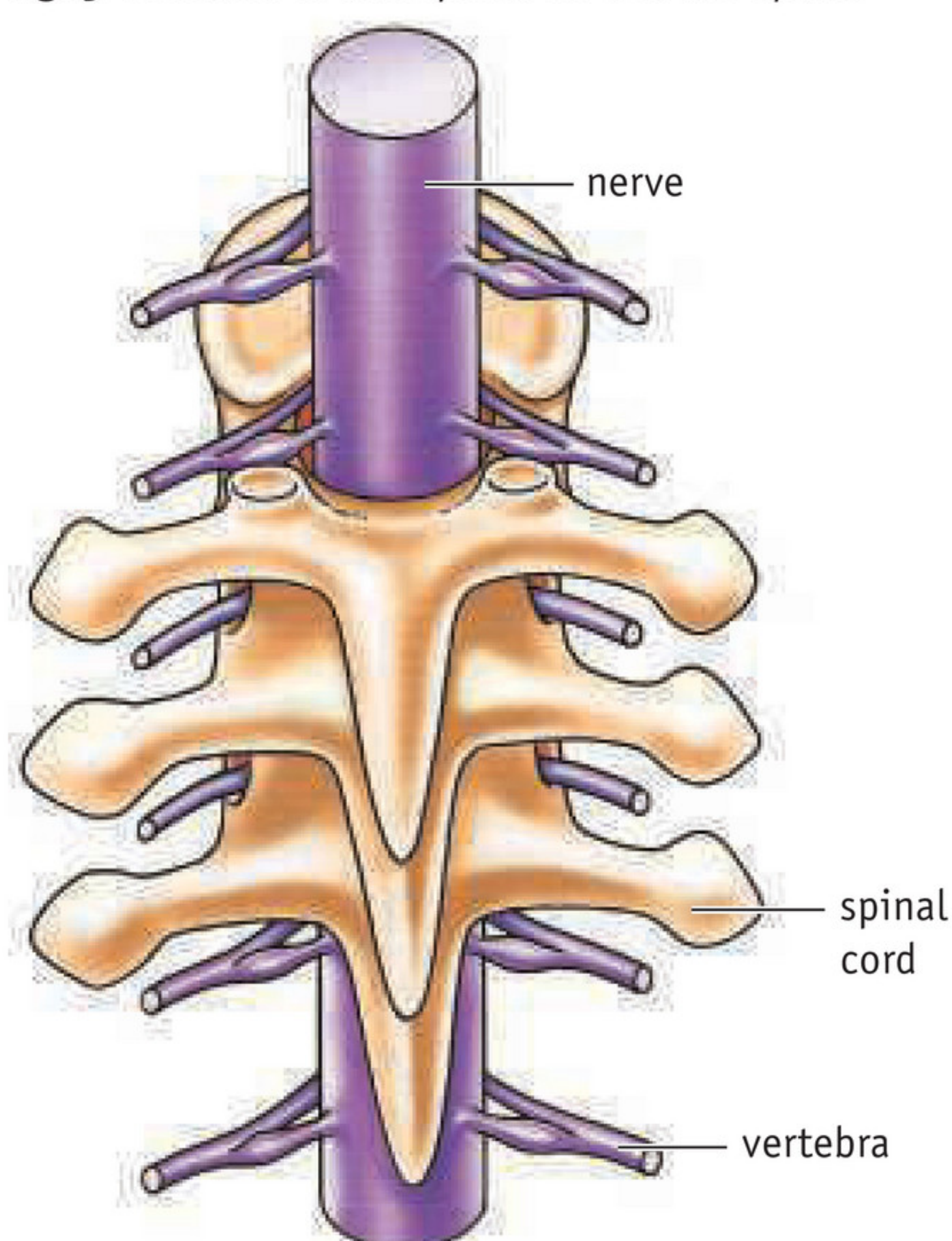
In the body, a single impulse is never passed to the central nervous system or to a muscle or gland via just a single axon. In reality, impulses are passed via thousands of axons at the same time. The axons are bundled together in a **nerve** (see figure 4). Each axon in a nerve is surrounded by a thin layer. This layer insulates the axons from each other. A nerve has a tough protective layer around it.

fig. 4 Nerve with several nerve cells.



The nerves connect the central nervous system to all parts of the body (see figure 1). Body parts in the head and the neck are connected directly to the brain by nerves. The torso and limbs are connected to the spinal cord by nerves. Impulses are passed to the brain through nerves in the spinal cord. The spinal cord starts at the brain and ends in the lumbar vertebrae in the lower back. The spinal cord is surrounded by the backbones of the vertebral column (see figure 5).

fig. 5 Location of the spinal cord in the spine.



PATHS TAKEN BY NERVE IMPULSES

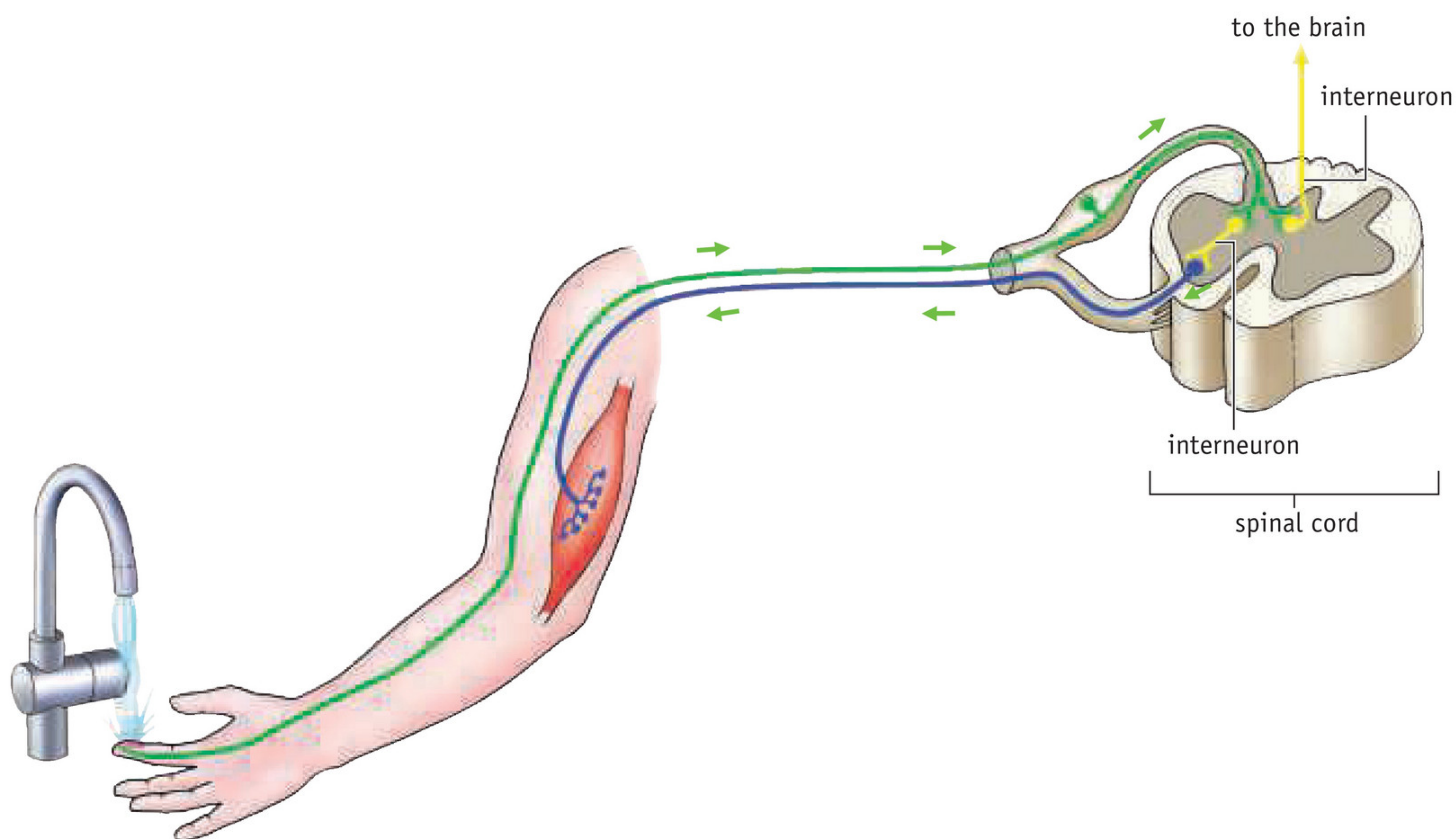
Nerves can be very long, sometimes as much as a metre. The impulses then have to cover large distances through the nerves. Even so, you can react very quickly. The impulses are conducted through the nervous system at high speeds.

When reacting to stimuli, impulses can travel through the nervous system in various ways. In a **conscious reaction** (voluntary responses), impulses first go from your senses to your brain. You become aware of the stimuli that your senses are receiving. You decide how you want to react, then impulses go from your brain to your muscles. Your muscles contract and you react.

In a reflex, the impulses do not go through your brain (except for reflexes that take place in your head, such as a watering mouth). A **reflex** is a fixed, fast and involuntary reaction to a certain stimulus. Examples of reflexes are the withdrawal reflex, the eyelid reflex and the pupillary reflex.

Figure 6 shows an example of a withdrawal reflex. You are going to wash your hands. The water turns out to be very hot. The moment you touch the hot water, you immediately withdraw your hand. You will only register the pain afterwards.

fig. 6 Withdrawal reflex.



The hot water on your hand creates impulses in sensory cells in your skin. Those impulses are passed to your spinal cord through nerve cells. The spinal cord and the brain have **interneurons**. These are nerve cells that conduct impulses within the central nervous system, from one nerve cell to another. The interneurons in the spinal cord immediately pass the impulses to nerve cells in the arm muscles. As a result, your arm muscles contract, which makes you pull your arm away.

The interneurons also conduct impulses to the brain. However, the path from the spinal cord to the brain is longer than the path from the spinal cord to the arm muscles. As a result, you pull your hand away first and only feel the pain afterwards. The path that impulses take in a reflex is called a **reflex arc**. The speed of reflexes is often needed to protect your body against injuries.

KNOWLEDGE

1

- a** What are the components of the central nervous system?
- b** connect the central nervous system to all parts of the body.
- c** Carly is tapped on her shoulder and she turns her head around.
How does Carly become aware of the tapping on her shoulder?
- d** How do her neck muscles react when impulses arrive there?
- e** Carly is offered a piece of chocolate by a classmate. Impulses arrive at her salivary glands.
These impulses were created in her *brain / muscles / senses*.

2

- The nervous system contains millions of nerve cells.
- a** What are the components of a nerve cell?
 - b** What is a nerve?
 - ☐ A a bundle of nerve cell axons
 - ☐ B A cell that can conduct impulses
 - ☐ C two nerve cells that are connected together
 - c** What is the function of the layer around each axon in a nerve?
 - ☐ A to insulate the axons from one another
 - ☐ B to pass impulses to and from the cell body
 - ☐ C to protect the nerve
 - d** where in your nervous system do you find interneurons?
 - e** What is the function of interneurons?

3

- a** A conscious reaction to a stimulus has seven steps.
Put the steps in the correct sequence.
- The stimuli are converted into impulses.
- Impulses go from your brain via the spinal cord to your muscles.
- You decide how you want to react.
- Your muscles contract and you react.
- You become aware of the stimuli that your senses are receiving.
- 1 Your sensory cells receive the stimuli.
- Nerve cells transmit the impulses to the brain via the spinal cord.

- b** A reflex arc consists of five steps.
Put the steps in the correct sequence.
- The stimuli are converted into impulses.
- Your muscles contract and you react.
- 1 Your sensory cells receive the stimuli.
- Interneurons immediately pass the impulses to nerve cells in the muscles.
- Nerve cells transmit the impulses to the spinal cord.
- c** In a reflex arc, the interneurons also transmit the impulses to the brain. However, you only perceive the stimulus for a reflex after the reflex has happened.
Explain how.

4



Summary

Make a summary of this basic course material by completing the texts.

The nervous system is made up of:

-
-

The functions of the nervous system are:

-
-

A nerve cell consists of:

-
-
-

A nerve is

A reflex is a

The path that impulses take in a reflex arc:

.....

.....

.....

.....

INSIGHT

5

An axon of a nerve cell in the spinal cord can be up to one metre long.

- a** Give an example.
- b** The cell body of a nerve cell is located close to the spinal cord. A long axon from that cell passes impulses in towards the cell body.
This nerve cell is connected to *muscles / sensory cells*.
- c** Nerves connect the tongue to the central nervous system.
Which part of the central nervous system is the tongue connected to? Explain your answer.

6

Sometimes you wake up and you feel a strange tingling sensation in your arm or leg. Apart from that, you cannot feel it at all. You also can't lift that arm or leg either. You have probably been lying on your arm or leg so that blood vessels or nerves have been pinched, so your arm or leg has 'gone to sleep'.

- a** Explain why you cannot feel anything in an arm or leg that has 'gone to sleep'.
- b** Explain why you cannot lift an arm or leg that has 'gone to sleep'.

7

Somebody pushes against your back. You feel the push, look behind you and push back.

- a** Is pushing back a voluntary action or a reflex? Explain your answer.
- b** Put the sentences about the how this action proceeds in the correct sequence.
 - The pressure sensory cells receive stimuli.
 - The stimuli are converted into impulses.
 - Impulses from the brain are passed via the spinal cord to the muscles.
 - In your brain, you become aware of the stimuli that your senses are receiving.
 - You decide how you want to react.
 - Your muscles contract and you react.
 - Interneurons in your spinal cord pass impulses to your brain.
 - Nerve cells transmit the impulses to the spinal cord.
- c** Write down two functions of the brain in this action.

+ 8

When painful injuries are being treated, patients are sometimes given a local anaesthetic. The nerve cells that pass impulses from sensory cells, for example in a hand, are disabled.

- a** Is it possible that a patient will pull their hand away in a reflex movement during treatment? Explain your answer.
- b** Is it possible that a patient will pull their hand away deliberately during treatment? Explain your answer.

HOW IT FITS TOGETHER the living world

BORN WITH REFLEXES

Babies are born with various useful reflexes. The search reflex makes a baby automatically turn its head in the direction of something warm and soft that touches its cheek, such as its mother's breast. When a baby finds a nipple with its mouth, the sucking reflex is triggered. A baby can suck on the nipple very powerfully to get milk. The swallowing reflex lets the baby swallow the milk, which will then end up in the oesophagus. If a little milk gets into the windpipe by accident, the cough reflex is triggered. The powerful exhalation in a cough clears the respiratory tract. Irritant substances that get into a baby's nose trigger a sneeze reflex. A very powerful exhalation clears the substances from the nose.

fig. 7 A baby sneezing.



9

Read the text 'Born with reflexes'.

Reflexes are often needed to protect your body against injuries.

- a** What is the function of the search reflex, the sucking reflex and the swallowing reflex in babies?
- b** The plantar reflex makes a baby's toes curl when you press the sole of their foot. Describe the reflex arc that the impulses are passed along for the plantar reflex.
- c** What sensory cells in the foot are stimulated when you press the sole?
 sensory cells
- d** The reflexes of newborn babies are tested.
 Give two reasons why this is needed.

 Go to the *Flash cards* and the *Test yourself* section.

5 Behaviour

LEARNING OBJECTIVES

5.5.11 You can explain what behaviour is.

5.5.12 You can explain what determines behaviour.

5.5.13 You can explain the difference between observation and interpretation of behaviour.

► Learning how to do research 2

► Practical activity 7

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES					
	5.5.11	5.5.12	5.5.13	5.1.1*	5.4.8*	5.4.10*
Remembering	1	2cde				
Understanding	5	2ab, 3, 5	4, 5	10a	10c	
Using	6ab, 7, 8a		8e			
Analysing	6cd, 8bd	6d, 8c, 9ac, 10d	9b			10b

* You can find this learning objective in another Basics section.

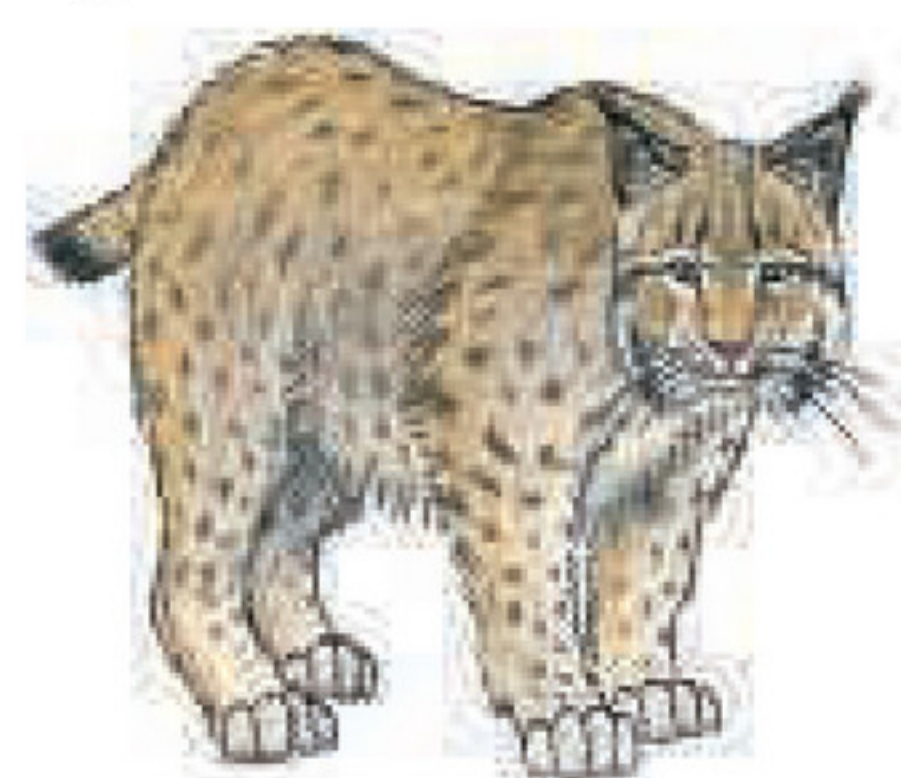
Everything that humans or animals do, such as laughing or looking at something, is behaviour. Making noises, sleeping, emitting scents and even standing still are examples of behaviour.

WHAT IS BEHAVIOUR?

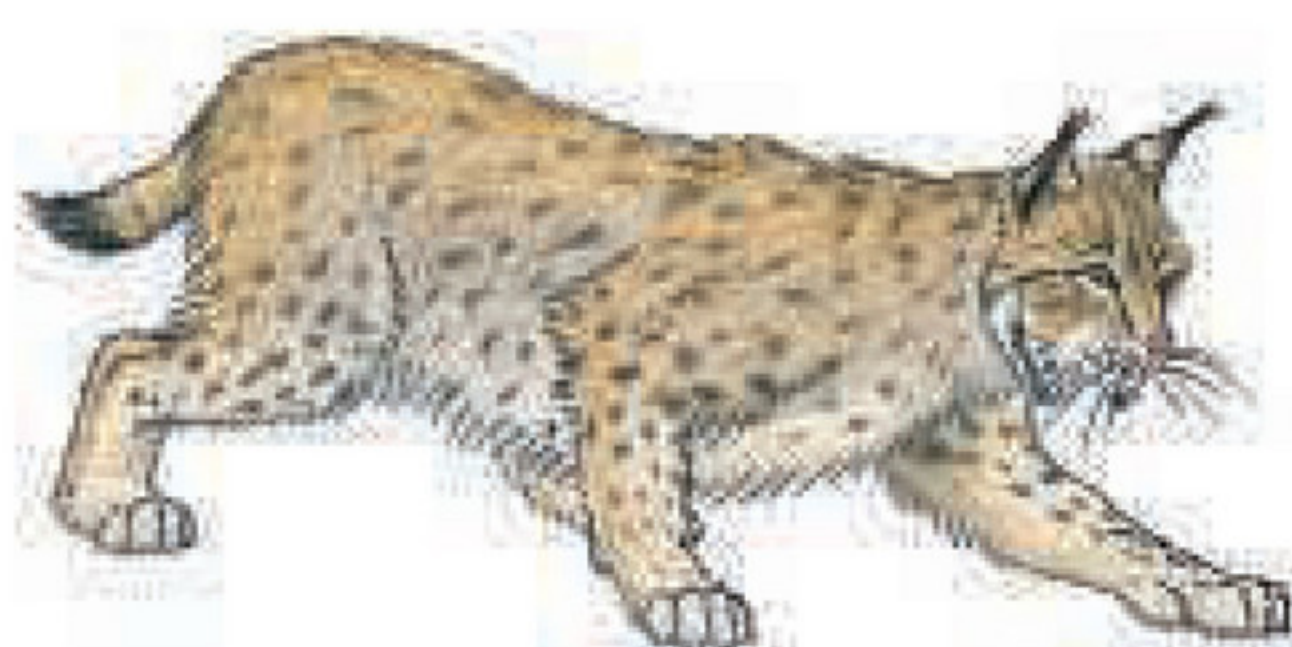
The behaviour of organisms consists of **actions** that are interrelated and have a goal.

Figure 1 shows the behaviour of a hunting lynx. The hunting behaviour of the lynx consists of interrelated actions such as stalking and sneaking up on the prey. The goal of hunting behaviour is to help stay alive. The various actions have a fixed sequence, with the effect of one action leading to the next. This is called a **chain of behaviour**. The effect of stalking, for instance, is detecting prey. This leads to the following action: creeping closer, etc.

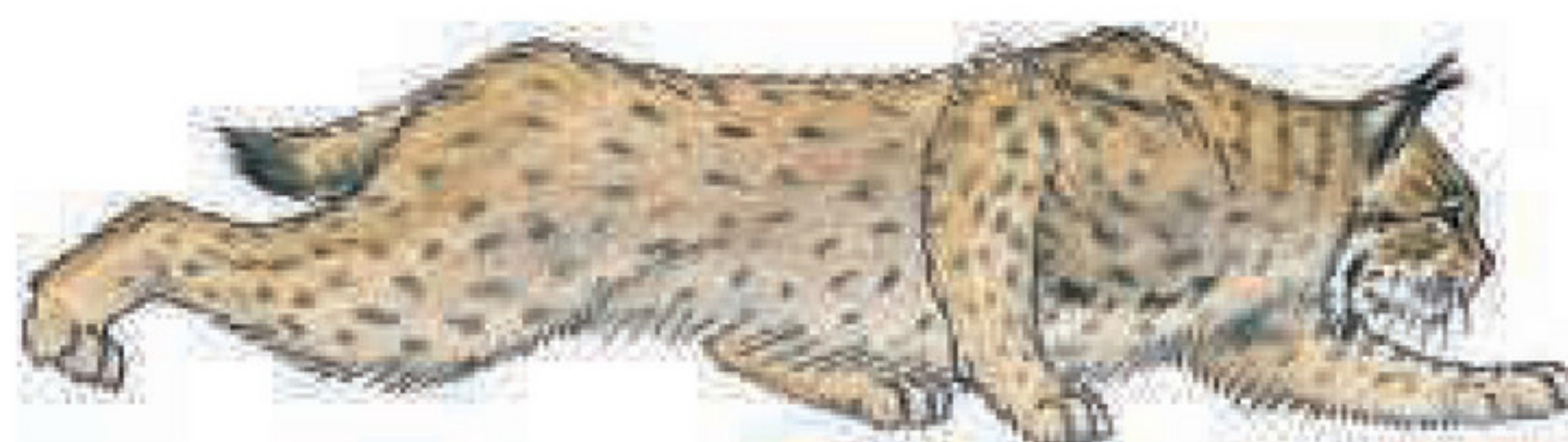
fig. 1 A chain of behaviour: the hunting behaviour of a lynx.



1 stalking



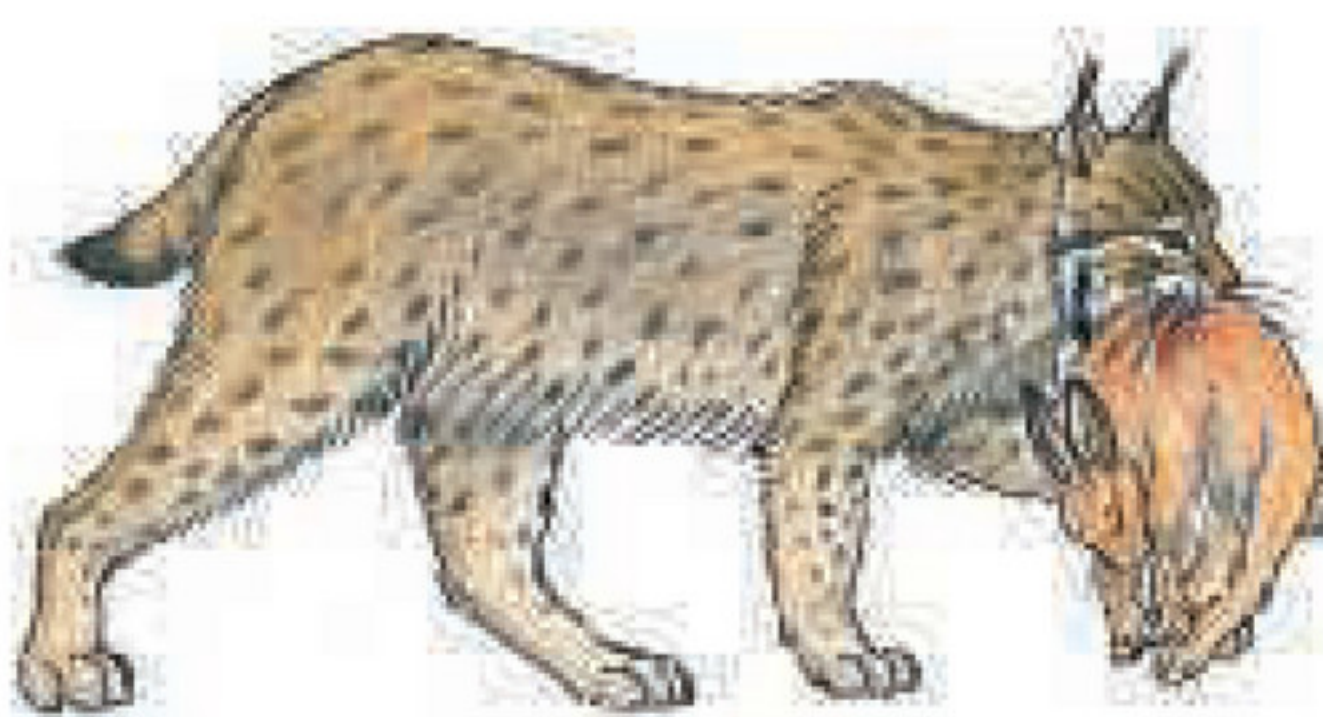
2 creeping closer



3 sneaking up on the prey



4 pouncing and killing



5 dragging the prey off

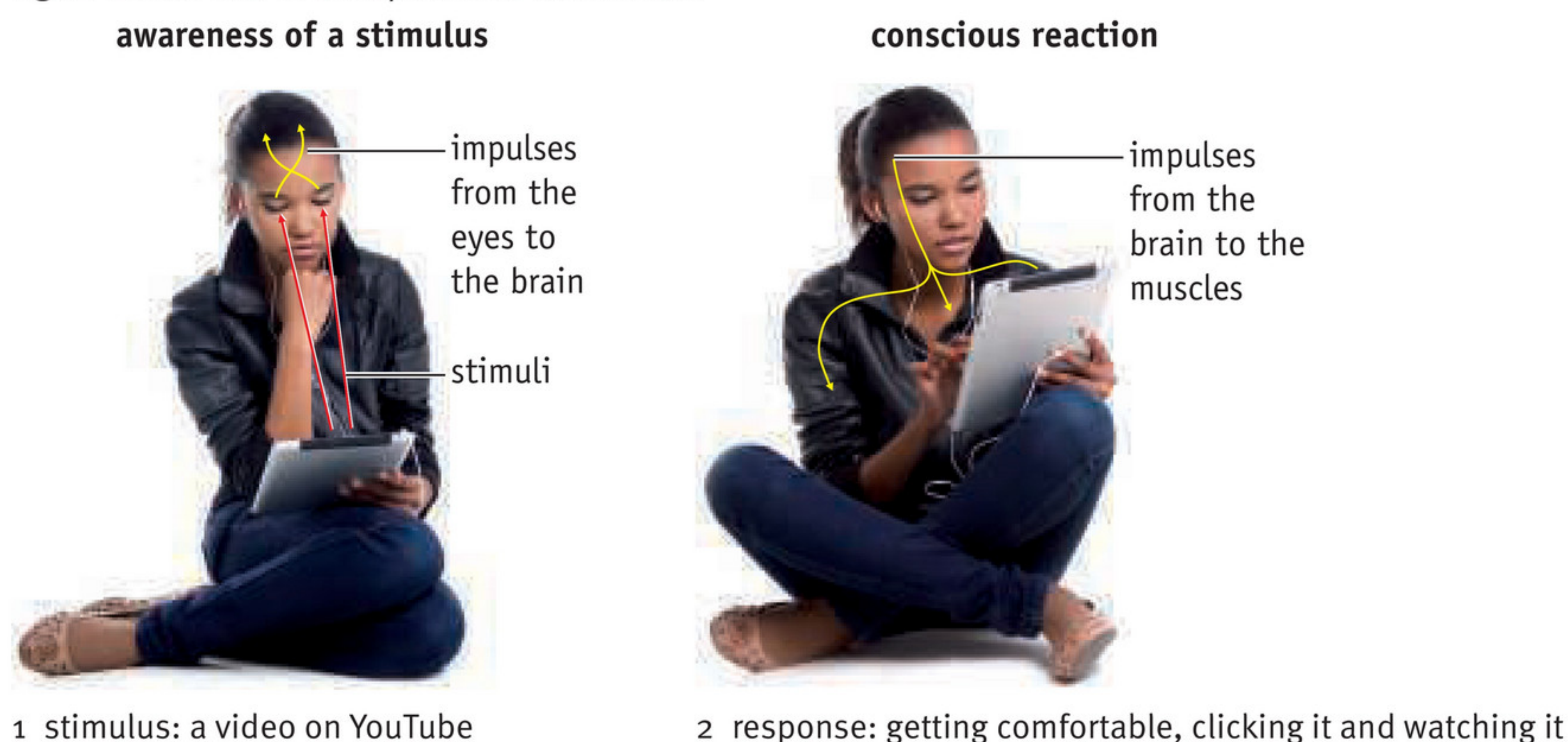


6 eating the prey

MOTIVATION

A stimulus is an influence from the surroundings on an organism. Senses react to stimuli by passing impulses to the brain. In a conscious reaction, the brain transmits impulses to the muscles. You can see an example of this in figure 2. The girl has found a clip she likes on YouTube. In her brain, she becomes consciously aware of this stimulus. She then responds to the stimulus: she makes herself comfortable, clicks the video and watches it. Impulses are then passed to her muscles. A reaction to a stimulus is called a **response**.

fig. 2 Behaviour is a response to a stimulus.



There are various types of stimuli: You can get hungry and want to eat. Being hungry is an **internal stimulus**: it is created inside the body. Other stimuli come from outside the body. You smell and see freshly baked bread, for example. An **external stimulus** comes from outside your body and you perceive it through your senses.

The **motivation** is the willingness to behave in various ways. If you have already eaten a lot, your motivation to eat another sandwich will be very low. The stimulus of 'smelling freshly baked bread' will not lead to eating behaviour. When you are hungry, though, your motivation to eat will be high. The stimulus of 'smelling freshly baked bread' will then lead to a response.

INNATE AND LEARNED

Behaviour is partly inborn (innate) and partly learned. Immediately after birth, young mammals can feed by sucking the nipple of their mother (see figure 3). This is an example of **innate behaviour**, because the young do not need to learn to do this. If a behaviour is a result of being taught or shown, it is **learned behaviour**. A toddler learns to use a spoon when eating and a cat learns to use the litter box.

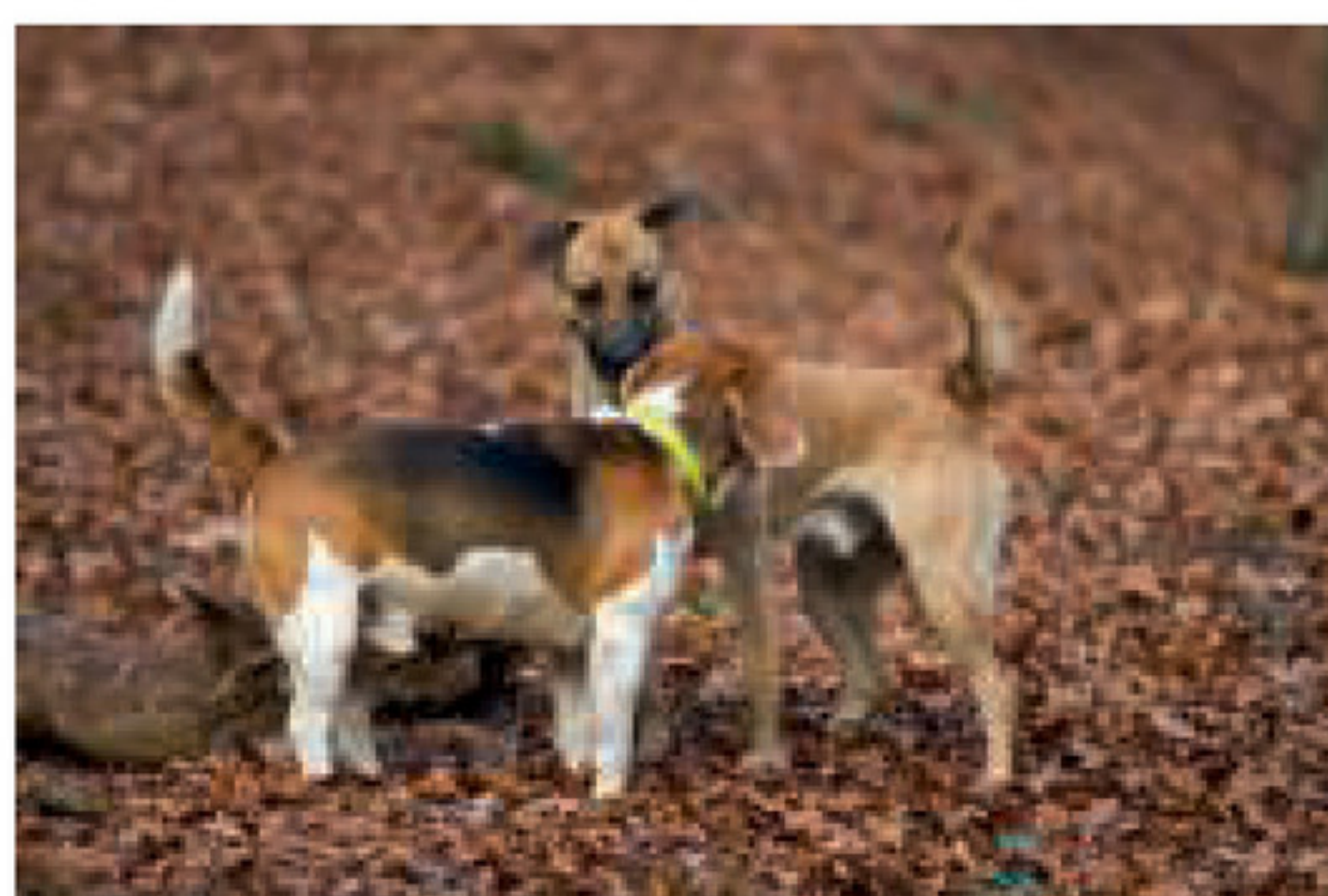
fig. 3 Innate behaviour in kittens.



SOCIAL BEHAVIOUR

In many animals (including humans), behaviour is influenced by other members of their species. The behaviour of members of a species towards each other is called **social behaviour**. In social behaviour, the action of one animal (or human) is a stimulus for an action by another member of the species. For example, if you see someone you know walking on the other side of the road and they put their hand up, you may wave back. A stimulus or action in social behaviour is called a **signal**. Raising the hand was a signal to another member of the species. Humans and animals use signals to communicate with each other. Examples of signals in humans are body posture, gestures and language. Animals often use colours, sounds or scents (see figure 4).

fig. 4 Scent is an important signal for dogs.



HUMAN BEHAVIOUR

Human behaviour is different from animals. Humans think about their behaviour and they judge the behaviour of others. Animals don't do that. Many people prefer it when the people around them behave mostly the same way they do. Different behaviour is often felt to be 'bad'. That is why people have norms and values for their behaviour: to help them live together.

Values are the things that people find important in life. Examples could be fairness, respect, justice and freedom. **Norms** are the rules of conduct that many people think you should follow. For example that you must not steal. Norms are based on values. The norm that you must not steal is based on the value of fairness, for example.

OBSERVATION AND INTERPRETATION

Raising a hand is a signal that can have different meanings (see figure 5). To understand what it means, you have to look not only at the hand but also at the situation, the facial expression and the posture. That is how you know that the girl in the picture wants to say something, that the mother is giving a high five and that the boy is greeting someone.

fig. 5 Raising a hand is a signal.



The actual behaviour that you perceive – someone raising their hand – is called an **observation**. The observation for a dog wagging its tail is that the dog is moving its tail up and down. What you think this behaviour means is called the **interpretation**. For example: the dog is happy (although another interpretation might be that it is trying to chase away a fly).

KNOWLEDGE

1

- a** What organisms show behaviour? *animals / humans / plants*
- b** What description belongs with which concept?
- | | | |
|----------------------|-----------------------|--|
| A chain of behaviour | ☐ | ☐ 1 the willingness to behave in specific ways |
| B response | ☐ | ☐ 2 influence from the environment |
| C stimulus | ☐ | ☐ 3 reaction to a stimulus |
| D motivation | ☐ | ☐ 4 a fixed sequence of actions, with the effect of one action leading to the next |

2

- a** Behaviour that young mammals show immediately after birth is *innate / learned*.
- b** A blackbird defends its territory against other members of its species. Is that social behaviour? Explain your answer.
- c** What is the name for an action that acts as a stimulus for an action by another member of the same species?
- d** What methods do animals often use to communicate with each other?
- e** Rules of conduct that many people think you should follow are called *norms / values*.

3

- a** Human behaviour is more strongly *innate / learned* than animal behaviour.
- b** Write down another difference between the behaviour of animals and humans.

4

Bert puts his hand up in class. His teacher thinks Bert wants to ask a question.

a This is the teacher's *interpretation* / *observation* of Bert's behaviour.

b Which of these sentences contain an observation?

- ☐ A A dog wags its tail back and forth.
- ☐ B A dog tries to chase away a fly by wagging its tail.
- ☐ C A classmate greets you by waving at you.
- ☐ D Someone raises their hand.

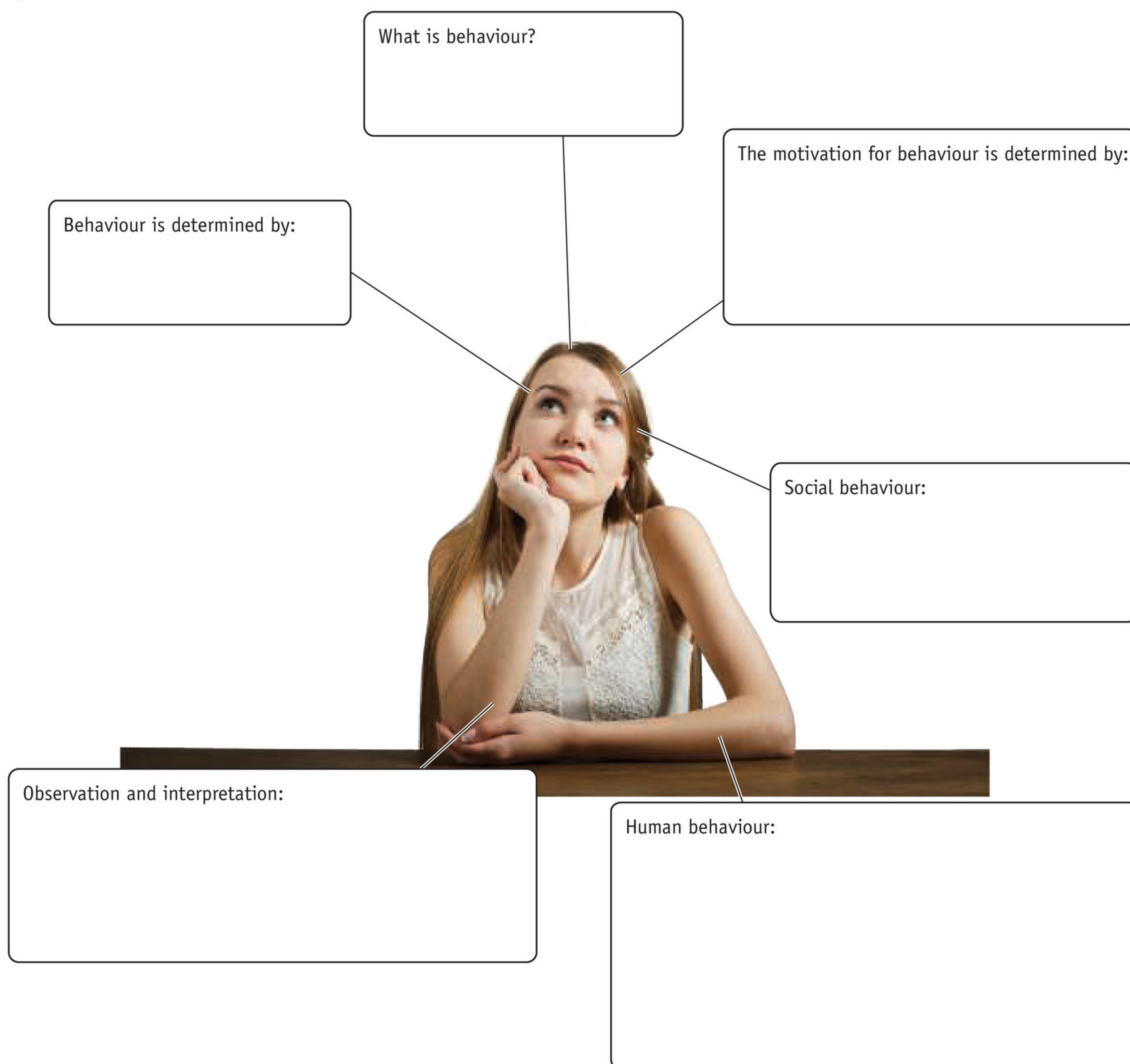
5

Summary

Make a summary of this basic course material by filling in the mind map in figure 6.



fig. 6



INSIGHT

6

- a** Which of these sentences are examples of behaviour?
- ☐ A An apple falls from a tree.
 - ☐ B A leaf grows towards the light.
 - ☐ C A boy is watching TV.
 - ☐ D A cat looks at the TV.
 - ☐ E A girl gets goosebumps.
 - ☐ F A plant is hanging limply.
- b** Serena is watching a romantic, emotional film. It makes her sad and she cries. Which sentence is correct?
- ☐ A The emotional film is a stimulus and crying is a response.
 - ☐ B Watching the emotional film and crying are a chain of behaviour.
 - ☐ C Watching the emotional film is a response and crying is a stimulus.
- c** In a response, impulses arrive at the and/or the
- d** Is a reflex or involuntary reaction a form of behaviour? Explain your answer.

7

A sparrowhawk is a bird of prey that takes up a lookout position in the sky by hovering. Hovering means staying in the same place in the air by beating its wings more rapidly. A sparrowhawk can do this to look for prey such as mice without moving its head.

- a** What is the motivation for a sparrowhawk to hover?
- b** Hovering is followed after some time by a stoop, a diving flight. What is the stimulus for stooping?
- c** Write down the actions in the behaviour chain of the sparrowhawk's hunt in the correct order.

8

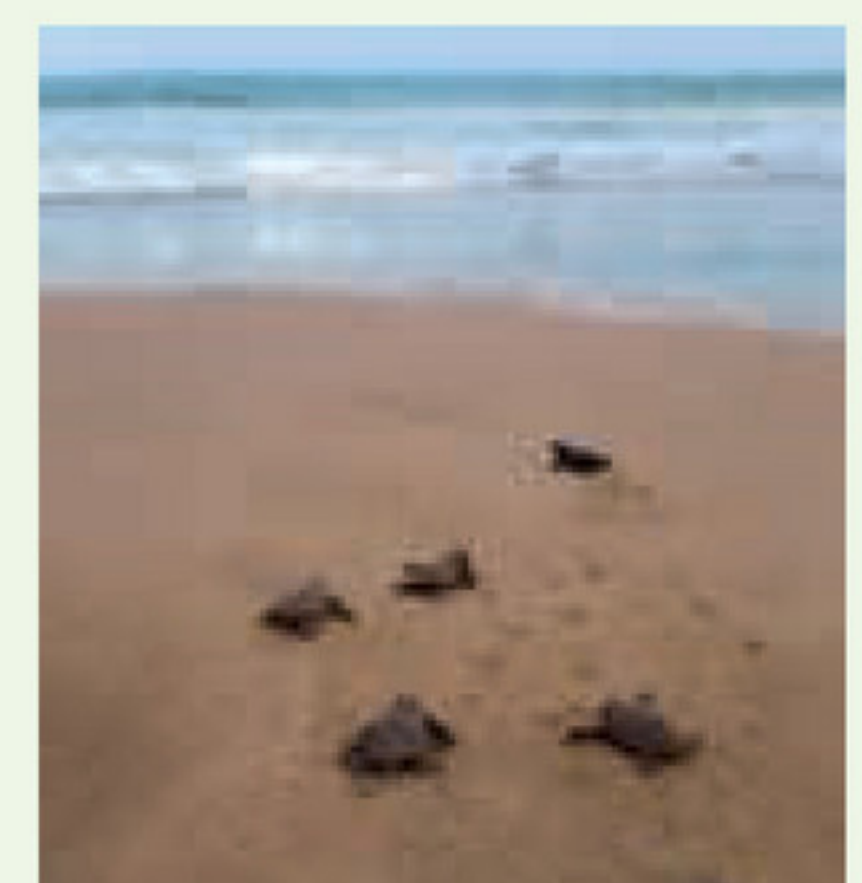
Read the text about 'Sea turtles' in figure 7.

- a** Which actions do young sea turtles do after hatching?
- b** Are the actions of young sea turtles part of a chain of behaviour? Explain your answer.
- c** Is the behaviour of the young sea turtles learned or innate? Explain your answer.
- d** The young sea turtles usually come out of their nest at night to head to the sea. At night, the sky above the sea is lighter than the sky above land. What stimulus makes the young sea turtles move towards the sea?
- e** International nature conservation organisations see *Caretta caretta* as vulnerable. Nevertheless, both the eggs and the meat are eaten by people in many countries. According to the *norms / values* of nature conservationists, you should not eat the eggs or meat of *Caretta caretta*.

fig. 7

Sea turtles

Marine turtles of the species *Caretta caretta* lay their eggs in a hole on the beach and then cover it with sand. When the young sea turtles hatch, they crawl out of the sand and move towards the water. The journey down the beach takes them about two minutes. They dive into the water and swim beyond the shallows to the deep ocean where they can grow into adult sea turtles.



+ 9

Read the text about 'Aposematism' in figure 8.

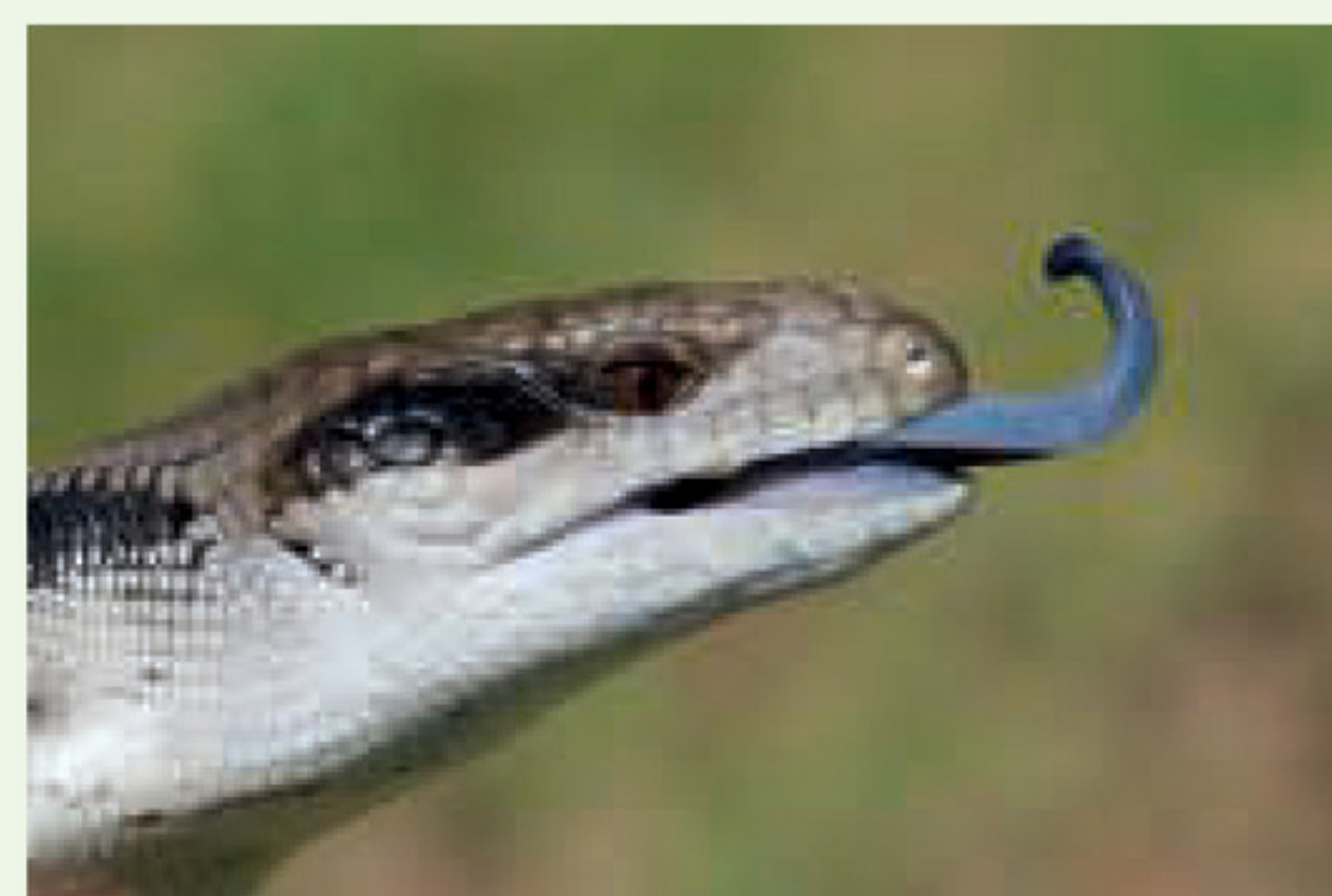
- a** Is aposematism a form of social behaviour? Explain your answer.
- b** Blue-tongued skinks have a blue tongue that they show unexpectedly to scare off enemies (see photo). This makes Britt think that a blue-tongued skink is poisonous. Is Britt's conclusion based on an observation or is it an interpretation? Explain your answer.
- c** There are also animals that use aposematism to look like dangerous animal species while in reality they are harmless. Some types of hoverflies look like wasps, for example. This is why birds do not catch and eat hoverflies. Is this behaviour in birds innate or learned? Explain your answer.

fig. 8

Aposematism

Some animals use bright colours to scare off other animals. This is known as aposematism. Their colours are a warning to enemies that the animal is poisonous or dangerous.

Sometimes the bright colours are hidden and you can only see them when an animal flies or runs away. Some frogs, for example, have bright-coloured thighs that are not visible until they jump away. Hidden bright colours, that are shown suddenly to scare, are called fright colours. The most common fright colours are red, yellow and blue. The photo shows you the blue tongue of a blue-tongued skink.



HOW IT FITS TOGETHER science

MIRROR TEST

Many animals respond to mirrors, but usually do not show that they recognise themselves in the mirror. Some animals even go and check behind the mirror. Scientists use the mirror test to determine whether animals recognise themselves in the mirror. Without the animal noticing, it gets marked with a cross or a dot, for example. The mark is applied in a place that the animal can only see in a mirror. In a study with Asian elephants, a cross was drawn on their foreheads. The elephant was then put in front of a mirror and the researchers checked whether the animal noticed that the mark was on its own body. The elephant would then touch the spot with its trunk. According to the behavioural biologist Frans de Waal, animals that recognise themselves in the mirror are more aware of their own existence (self-awareness), have better developed social relationships and are better able to relate to the behaviour of other members of their own species.

fig. 9 An elephant doing the mirror test.



10

Read the text about the 'Mirror test' and study figure 9.

- a** Where are the sensory cells located that the elephant uses for perceiving the cross on its forehead?
- b** The elephant touches the cross with its trunk.
Is this a voluntary reaction or a reflex arc? Explain your answer.
- c** Which part of the central nervous system are the impulses produced that make the muscles in the elephant's trunk contract?
- d** An important condition for demonstrating self-recognition using the mirror test is that the behaviour comes spontaneously.
Explain why the research is no longer reliable if the elephant has been able to practice a few times.

 Go to the *Flash cards* and the *Test yourself* section.

6 Regulation

LEARNING OBJECTIVES

5.6.14 You can say what feedback is and give examples of it.

5.6.15 You can describe how adrenaline, glucagon and insulin work.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES							
	5.6.14	5.6.15	5.1.2*	5.3.7*	5.4.8*	5.4.10*	5.5.11*	5.5.12*
Remembering	1, 2	3a						
Understanding	5	3bcde, 4, 5						
Using	6, 7a, 7c, 10a	8a, 9a				7a		10d
Analysing	7b	8b, 9bc	10c	10c	10c	7b	10b	10b

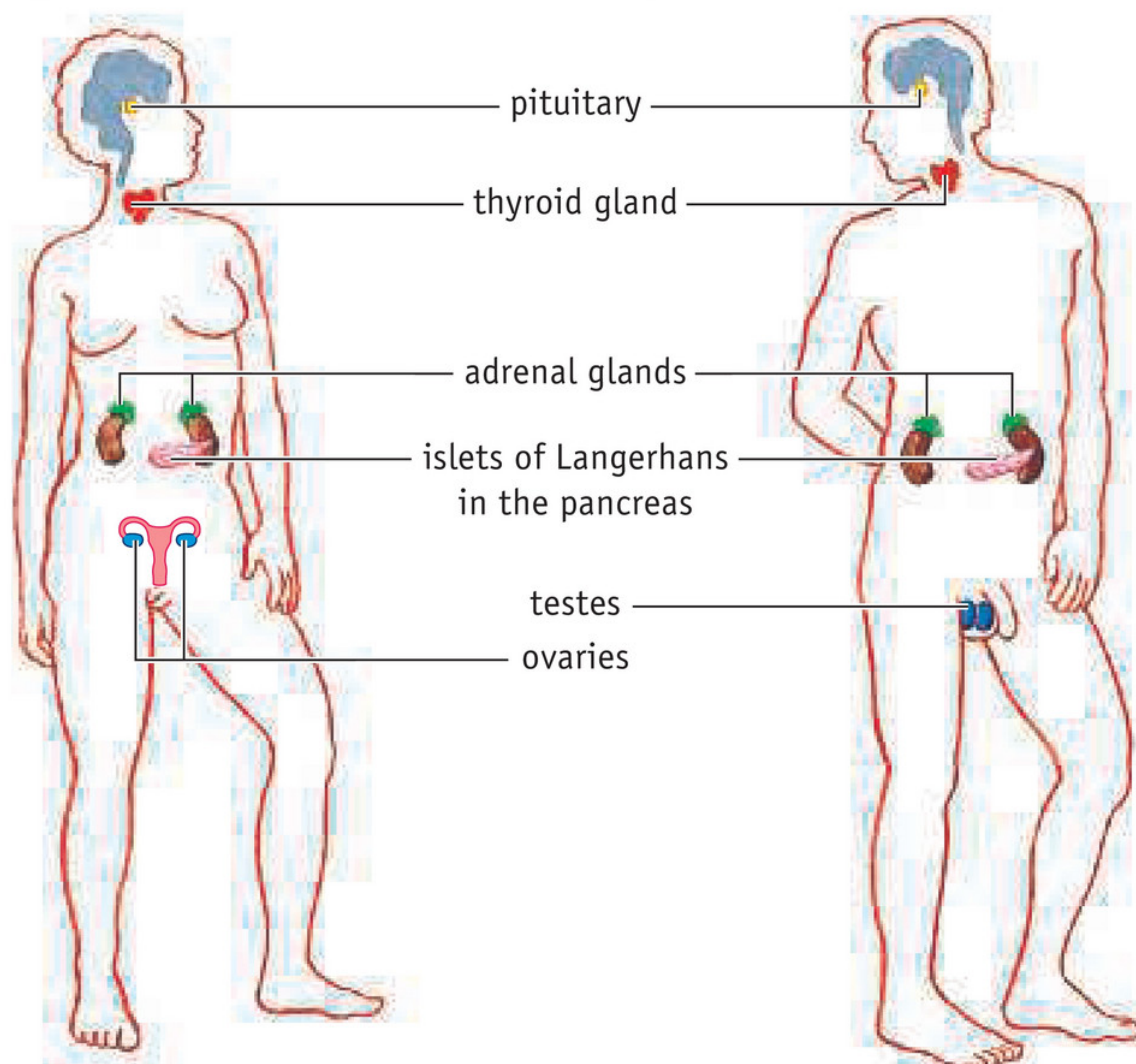
* You can find this learning objective in another Basics section.

The nervous system controls the operation of muscles and glands. Hormone glands produce substances that control processes in your body.

HORMONES

When controlling processes in your body, the nervous system often works together with the hormonal system. The **endocrine system** consists of a number of endocrine glands (see figure 1). A gland is an organ that produces substances, such as sweat glands, sebaceous glands and salivary glands. Endocrine glands produce hormones. **Hormones** are substances that control the functioning of organs.

fig. 1 The location of various endocrine glands.



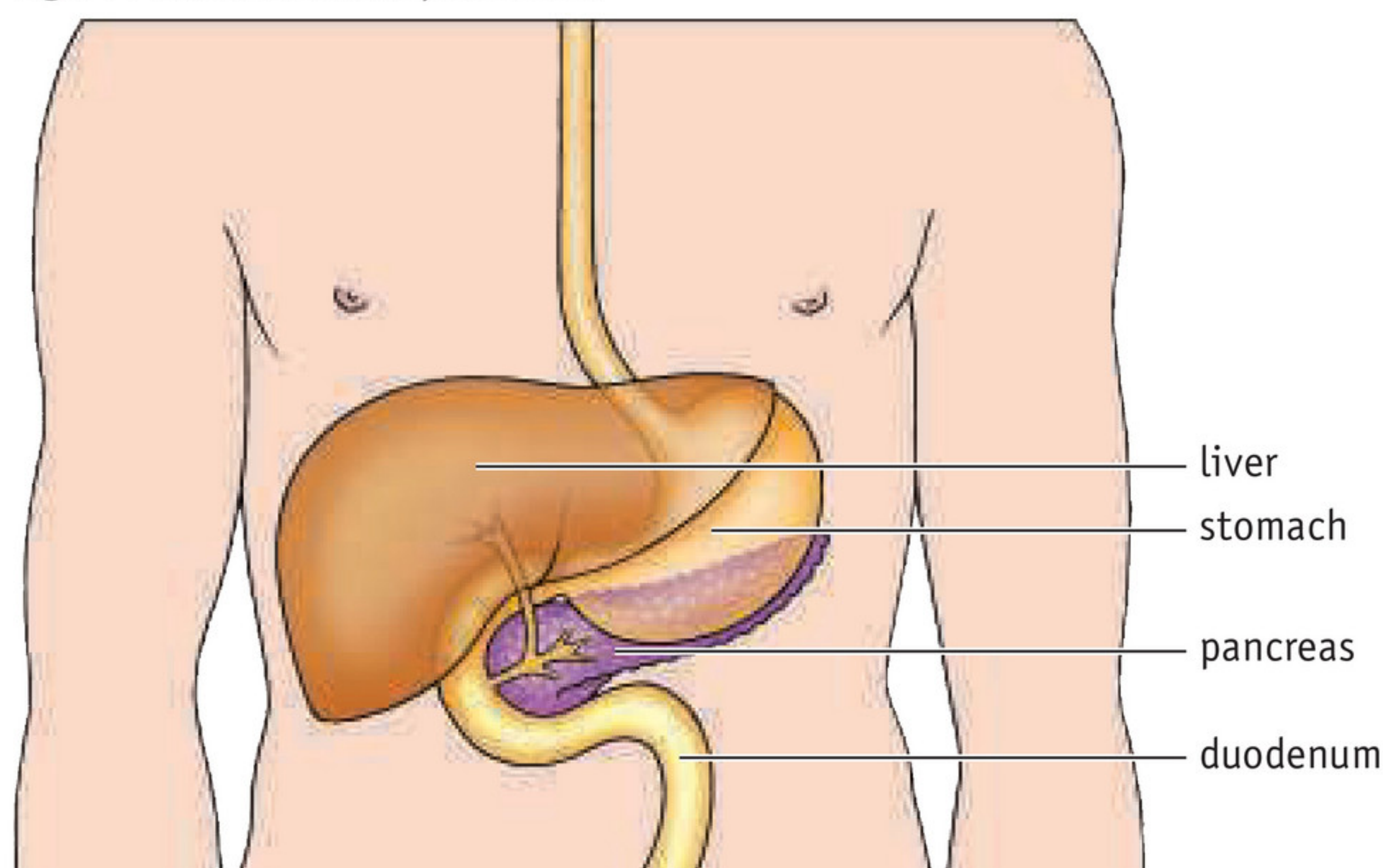
Endocrine glands secrete their hormones into the bloodstream. The hormones end up throughout the body via the blood. Hormones only have an effect in tissues and organs that are sensitive to that hormone. Important hormonal glands are the pituitary, the thyroid, the islets of Langerhans in the pancreas, the adrenal glands, the ovaries and the testes.

REGULATING THE GLUCOSE LEVEL

Glucose is a sugar produced by plants in photosynthesis. Food that comes from plants has glucose. Glucose is a fuel for the cells in your body. The cells get energy from glucose.

Glucose from your food is taken up in the blood through the wall of the small intestine. A lot of glucose may end up in the blood after a meal. The amount of glucose in the blood is called the **blood sugar level**. It is important for your body that the blood sugar level does not get too high and that it does not drop too low. Hormones from the pancreas (see figure 2) regulate the amount of glucose in the blood.

fig. 2 Location of the pancreas.



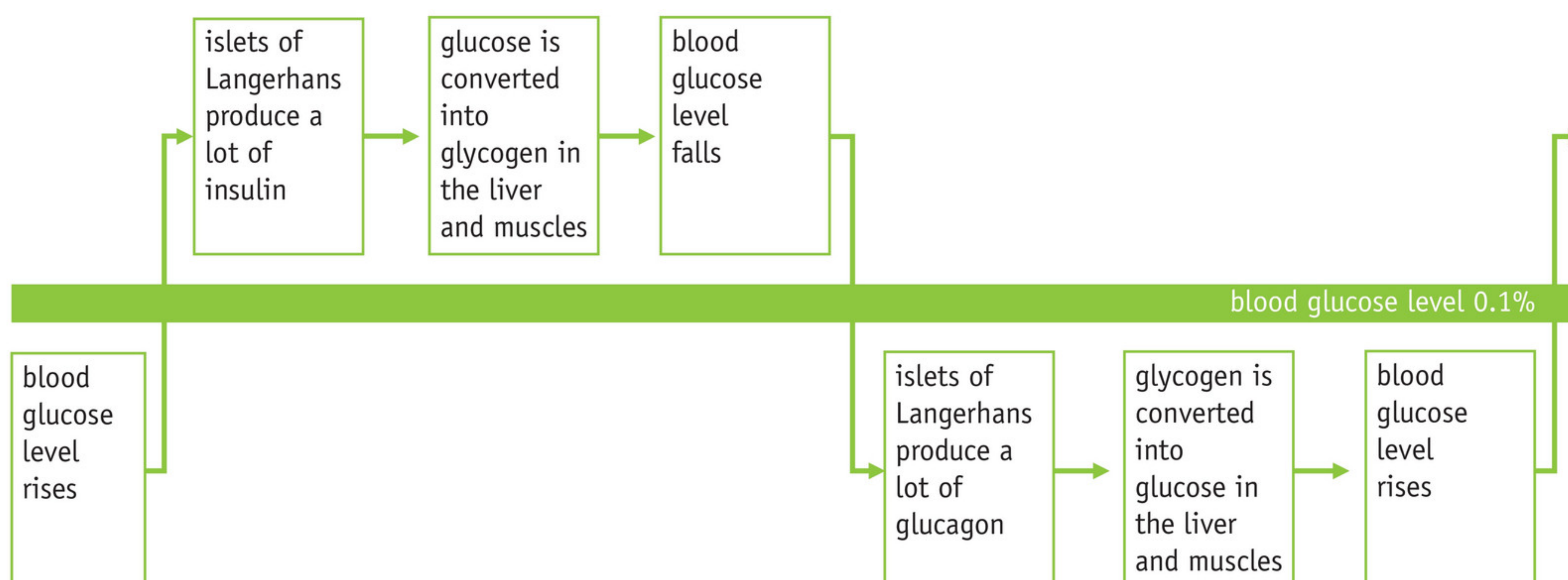
The pancreas is where the **islets of Langerhans** are. These are groups of cells that produce the hormones insulin and glucagon. Those two hormones regular the blood sugar level. They keep the level of glucose in the blood at roughly 0.1%. After a meal, the glucose level may be higher than 0.1%. The islets of Langerhans then respond by producing a lot of **insulin**. Insulin makes the liver and muscles convert glucose into **glycogen**. Glycogen is a fuel reserve that is stored in the liver and muscles. Because glucose is converted into glycogen, the blood glucose level decreases. Your cells need a lot of energy during physical exercise. The cells then take in glucose from the blood to use as fuel. When the blood glucose level gets below 0.1%, the islets of Langerhans start producing a lot of **glucagon**. Glucagon makes the liver and muscles convert glycogen into glucose. The glucose is taken up in the blood. As a result, the blood glucose level rises again.

FEEDBACK

You can make a schematic diagram of the regulation of the blood sugar level (see figure 3). You can see that the process is continually being adjusted so that the level of glucose in the blood is kept roughly constant. If the glucose level gets too high, the islets of Langerhans start producing insulin. If the level gets too low, they start making glucagon. This method of adjustment is called **feedback**. The result of a process then triggers an adjustment of the process:

- glucose level too high
- causes an adjustment (production of insulin)
- the result of this (the blood glucose level goes down)
- causes another adjustment (production of glucagon), and so forth

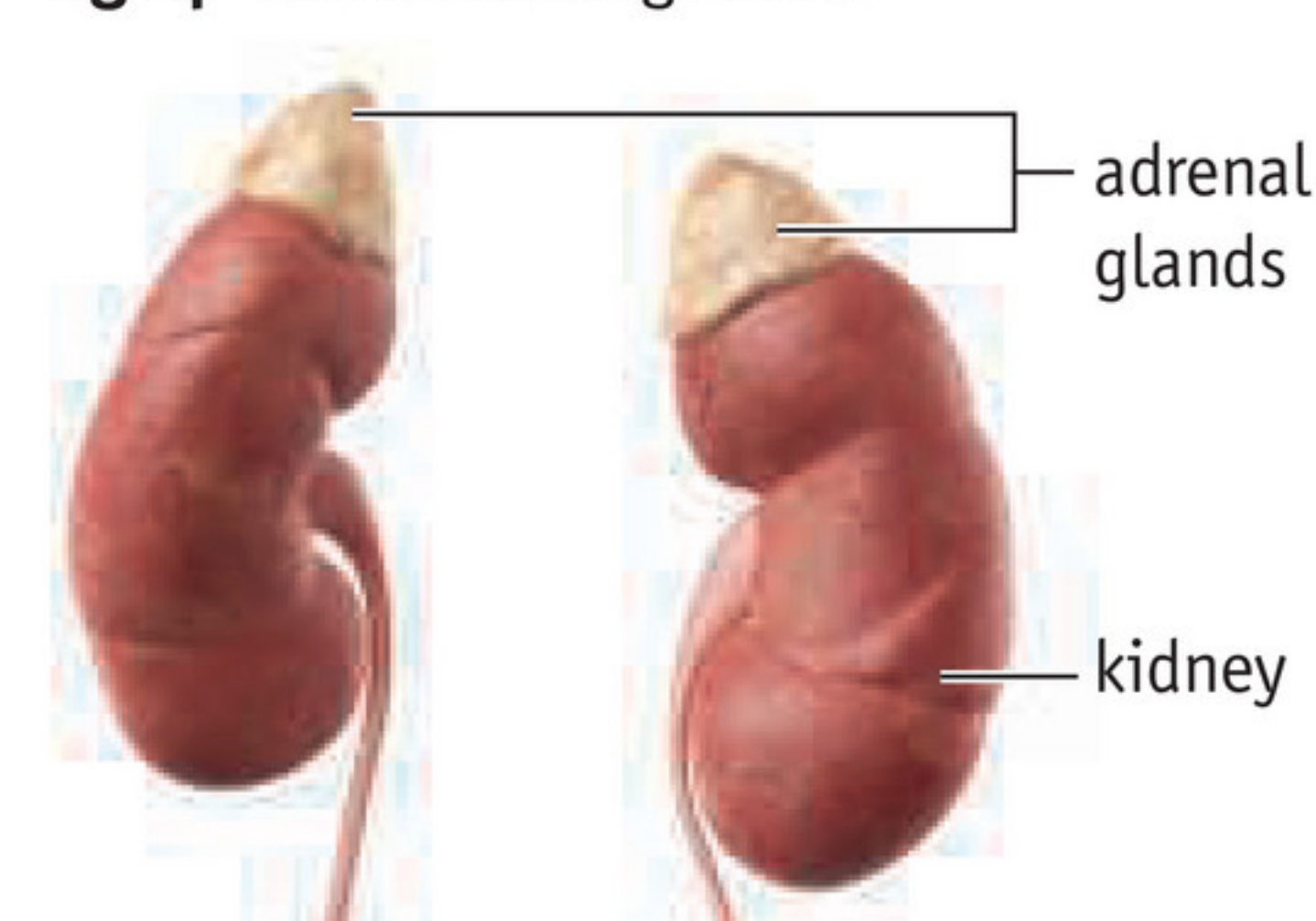
fig. 3 Regulation of the blood sugar level.



ADRENALINE

The adrenal glands are like caps on top of the kidneys (see figure 4). When you are furious or scared of something, the adrenal glands release the hormone **adrenaline** into the blood. Adrenaline makes the liver convert glycogen into glucose. As a result, the blood glucose level rises. Adrenaline also makes your heart beat more rapidly and makes you breathe faster. This is how adrenaline gets your body ready to act quickly in urgent situations. Adrenaline is therefore also known as the 'fight-or-flight hormone'. Adrenaline is the only hormone with a fast, short-term effect.

fig. 4 The adrenal glands.



KNOWLEDGE

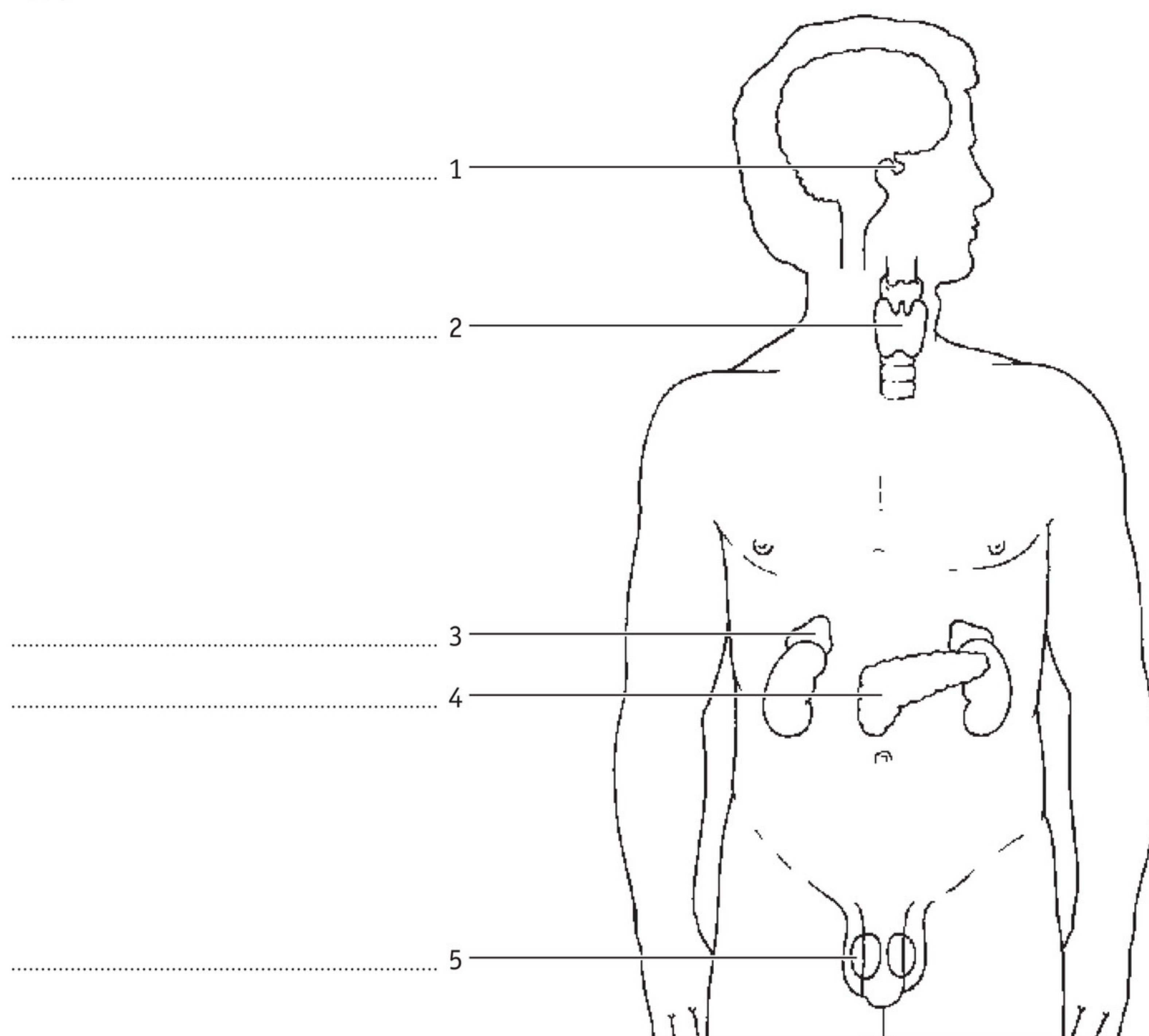
1

You can see the location of various endocrine glands in figure 5.

- Write down the names of the numbered endocrine glands.
- Colour in the various parts in the drawing. Give each endocrine gland its own colour.



fig. 5



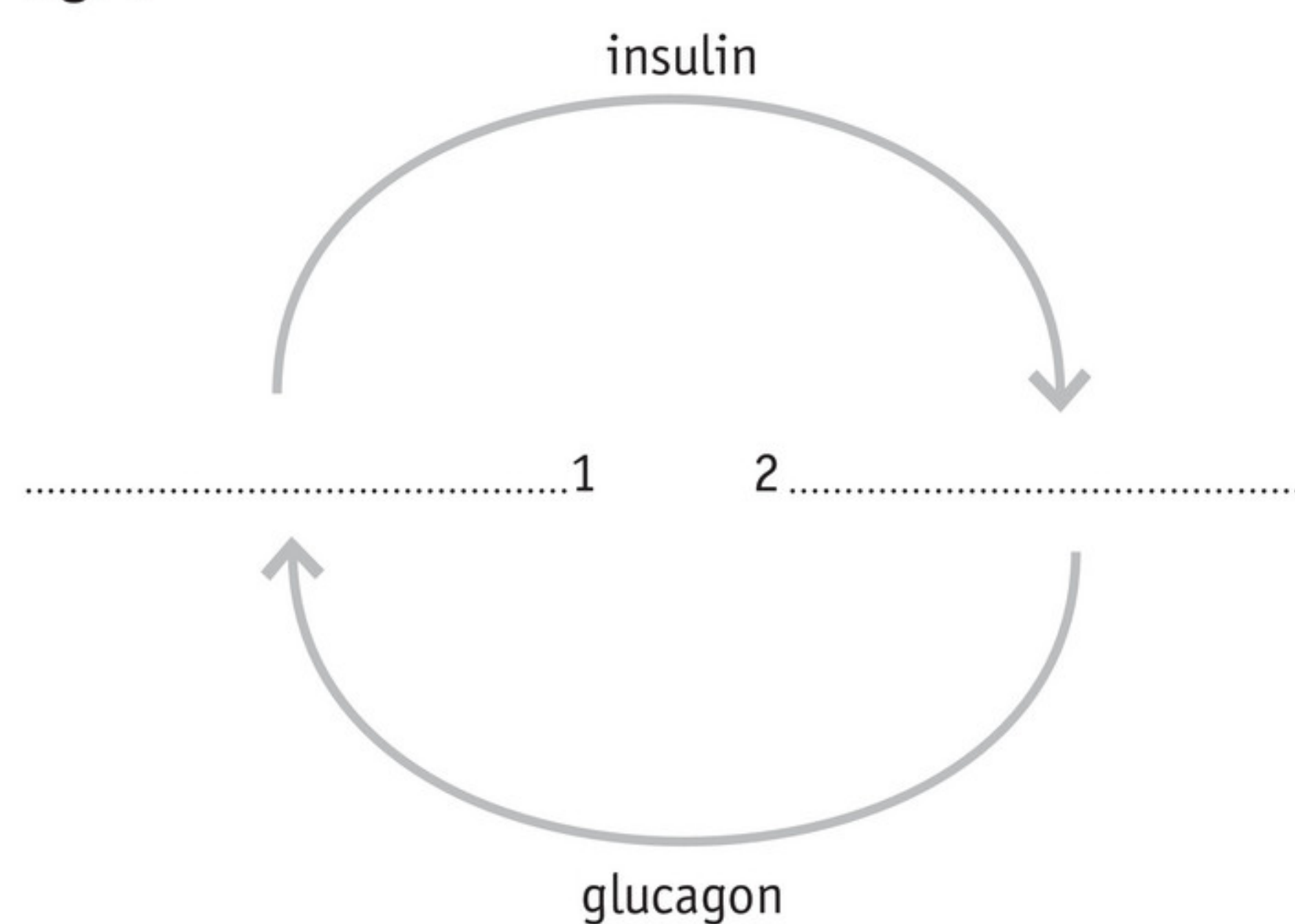
2

- a** What are hormones?
b How do hormones get to the organs whose function they control?
c Which organ contains the islets of Langerhans?
d Where is each hormone produced?
- | | | |
|---|------------|---------------------------------------|
| 1 | adrenaline | adrenal glands / Islets of Langerhans |
| 2 | glucagon | adrenal glands / Islets of Langerhans |
| 3 | insulin | adrenal glands / Islets of Langerhans |

3

- a** What is the function of the hormones that are produced by the islets of Langerhans?
b If the glucose level in the blood gets higher than 0.1%, the islets of Langerhans respond to this by producing a lot of *glucagon* / *insulin*. This results in *more* / *less* glucose being changed into glycogen so that the blood contains *more* / *less* glucose.
c If the glucose level in the blood drops below 0.1%, the islets of Langerhans respond to this by producing a lot of *glucagon* / *insulin*. This results in *more* / *less* glycogen being converted into glucose so that the blood contains *more* / *less* glucose.
d The drawing in figure 6 shows a part of the regulation mechanism for blood sugar levels. Complete the figure. Use the terms: *glucose* – *glycogen*.
e Explain why figure 6 shows a feedback mechanism.

fig. 6



4

Which statements about adrenaline are correct?

- ☐ A Adrenaline has a long-term effect.
- ☐ B Adrenaline makes the heart beat faster.
- ☐ C Adrenaline ensures that glucose is stored as glycogen.
- ☐ D Adrenaline makes you breathe more slowly.
- ☐ E Adrenaline lets you react more quickly.

5



Summary

Make a summary of this basic course material. Use the following words: *adrenaline – adrenal glands – hormones – endocrine glands – endocrine glands in humans – insulin and glucagon – regulation of the blood sugar level – feedback.*

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INSIGHT

6

The ovaries (see figure 1) produce hormones.

- a** Can hormones from the ovaries also be found in the blood in a woman’s finger?
Explain your answer.
- b** The hormones from the ovaries are not active in a woman’s finger.
Explain how.

7

When controlling processes in your body, the nervous system often works together with the hormonal system. These two organ systems do not work in the same way.

- a** The speed of the regulation is *high / low* in the nervous system and *high / low* in the hormonal system.
- b** The duration of the regulation is *short / long* in the nervous system and *short / long* in the hormonal system.
- c** Martin has diabetes and injects the hormone insulin twice a day.
Explain why insulin is said to be a hormone.

8

Read the text 'Diabetes' in figure 7.

- a Explain how Rebecca can regulate her own blood glucose level.
- b There was one time when Rebecca took an incorrect dose of insulin. It made her feel weak and shaky. The complaints went away after she ate a sugar cube. Did Rebecca inject too much insulin or too little? Explain your answer.

fig. 7

Diabetes

There are different types of diabetes. Diabetes types 1 and 2 occur most often.

Rebecca has type 1 diabetes. Her islets of Langerhans produce no insulin at all. She has to check the glucose level in her blood several times a day and inject insulin. Approximately 90% of diabetes patients have type 2 diabetes. In this type of diabetes, the islets of Langerhans do not produce enough insulin. The number of people with type 2 diabetes is increasing substantially, including among young people. Being overweight and short of exercise increase the risk of type 2 diabetes. Type 2 diabetes can be treated with medication, but eventually many patients with type 2 diabetes also have to inject insulin (see photograph).

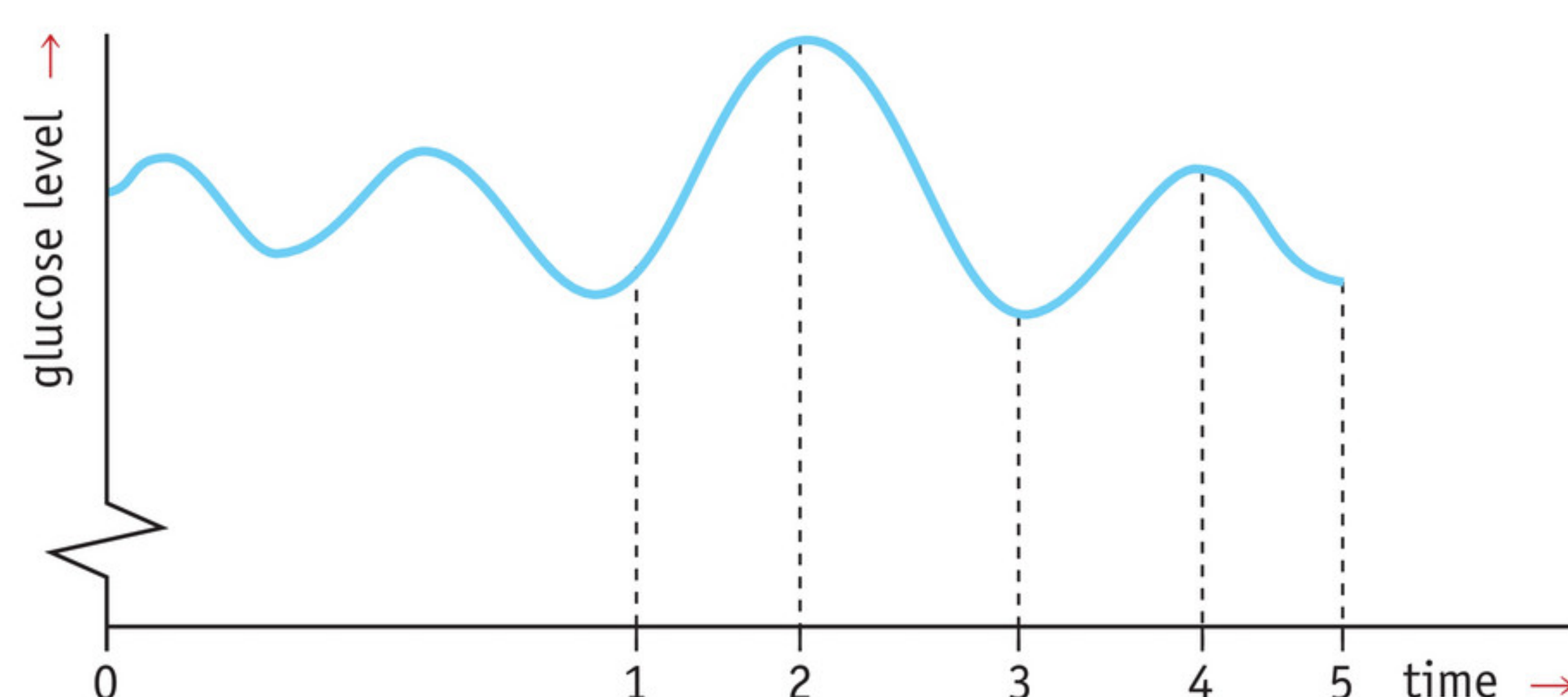


+ 9

Figure 8 is a diagram showing how the glucose level in the blood in an artery in a woman's leg changes over time. This woman does not make any major physical effort at any point. At time 1, she eats a couple of sandwiches with strawberry jam. She then eats nothing else until time 5.

- a Explain what causes the rise in the blood glucose level between times 1 and 2.
- b Which hormone affects the blood glucose level between times 2 and 3? Explain your answer.
- c Which hormone affects the blood glucose level between times 3 and 4? Explain your answer.

fig. 8



HOW IT FITS TOGETHER the living world

A ROLLERCOASTER RIDE

The first-ever rollercoaster was opened in New York in 1884. Since then, fans have been craving ever faster and more sensational rollercoasters. In a rollercoaster, your body has to handle all kinds of forces and sensations, and adrenaline is a natural stimulant. When the wagon is pulled up at the start of the ride, your adrenalin production increases. Your body prepares for action and you feel like you have a lot of energy (a kick). Under the influence of gravity, the wagon moves down quickly. Your body is then exposed to various speeds, loops and obstacles. Your balance organs are confused by the bends and descents. A rollercoaster ride can cause dizziness and nausea. You can also get muscle pains because your body gets violently shaken. But apparently the fun outweighs the negative effects of a rollercoaster ride because people gladly continue to get on rollercoasters!

fig. 9



10

Read the text called 'A rollercoaster ride'.

Excitement increases adrenaline production. Thrill-seekers are people who are always looking for that excitement. They look for increasingly dangerous situations to get an adrenaline kick.

- a** Explain why thrill seekers get a kick from adrenaline.
- b** Is the motivation to get on a rollercoaster innate or learned? Explain your answer.
- c** Your sense of balance makes sure that you stay upright. It sends impulses to the brain so that it knows what 'upright' is. Another sense plays a role in maintaining your balance.
What sense is that? Explain your answer.
- d** In young people, the motivation to get onto a rollercoaster can also be related to peer pressure. If you haven't been on the biggest rollercoaster around, you don't belong. Is this an example of social behaviour? Explain your answer.

 Go to the *Flash cards* and the *Test yourself* section.

How it fits together

DIGGING FOR WHITE GOLD

When the leaves start to fall, the hunting season begins. Not for game, but for the reproductive organs of the Tuber fungus – truffles!

Few foods are as expensive as the white truffle. Restaurant chefs pay thousands of euros per kilo for them. That's why these toadstools are sometimes also known as 'white gold'. Truffles taste like the smell of a leather jacket, or like rain on ploughed soil. And many people love that flavour. You can eat truffles shaved over a pasta dish, for instance. A lot of work is needed to get truffles on your plate. The toadstools are scarce and hard to find. They grow under the ground, usually near the roots of oak trees, and are not visible to the naked eye.

GREEDY PIGS

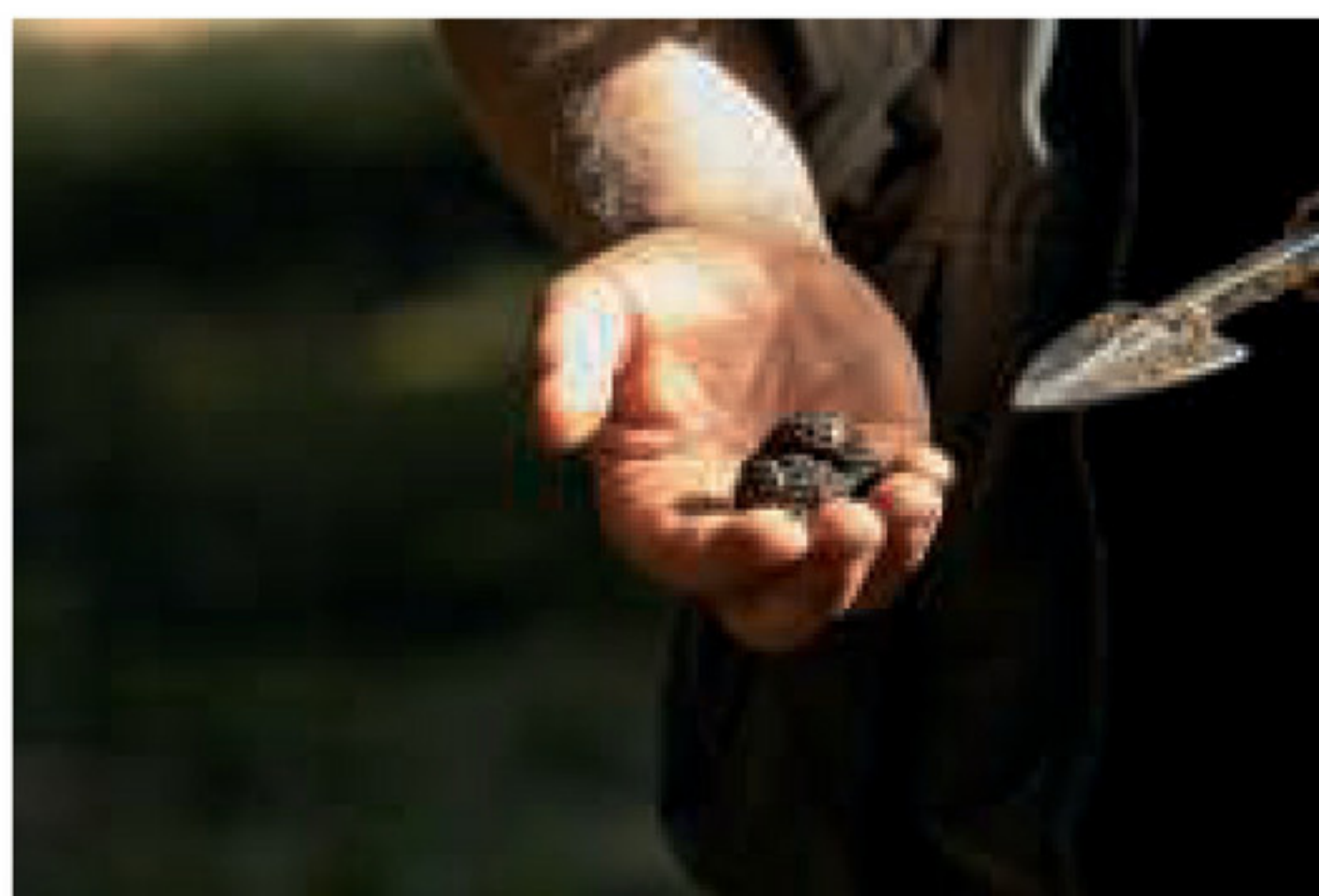
Fortunately, animals can help people find truffles. For centuries, truffle hunters have taken pigs with them on the search. Pigs may have poor eyesight, but they are experts at finding truffles. The females (sows) are so keen on truffles that they can smell them up to a metre underground. This is because truffles emit an odour very similar to the odour emitted by male pigs (boars) during the breeding season.

Using pigs to help find truffles has a few disadvantages. When a pig finds a truffle, she roots it out of the ground with her snout and (if the truffle hunter isn't paying attention) immediately eats it. Some truffle hunters are short a finger or two because the pigs go for the truffles so greedily. The pig rooting about can also damage the truffle's mycelium. For that reason, the Italian government banned using pigs to find truffles in 1985.

fig. 1



1 truffle hunter with pig



2 truffle hunter with truffle

TRUFFLE TRAINING

Nowadays, truffle hunting is mostly done with dogs. Training starts when they are still a puppy. They drink milk from the mother dog whose nipples have been coated with truffle oil. Later, they play with truffles or tennis balls with truffle oil. The next step is that the truffles are hidden and the dogs have to find them. They criss-cross the terrain and when they smell one, they let the handler know by jumping around and barking.

In the high season for truffle hunting, some people are so fanatic that they steal or even poison truffle dogs. It's genuine gold fever – and just for a fungus.

EXERCISES

1

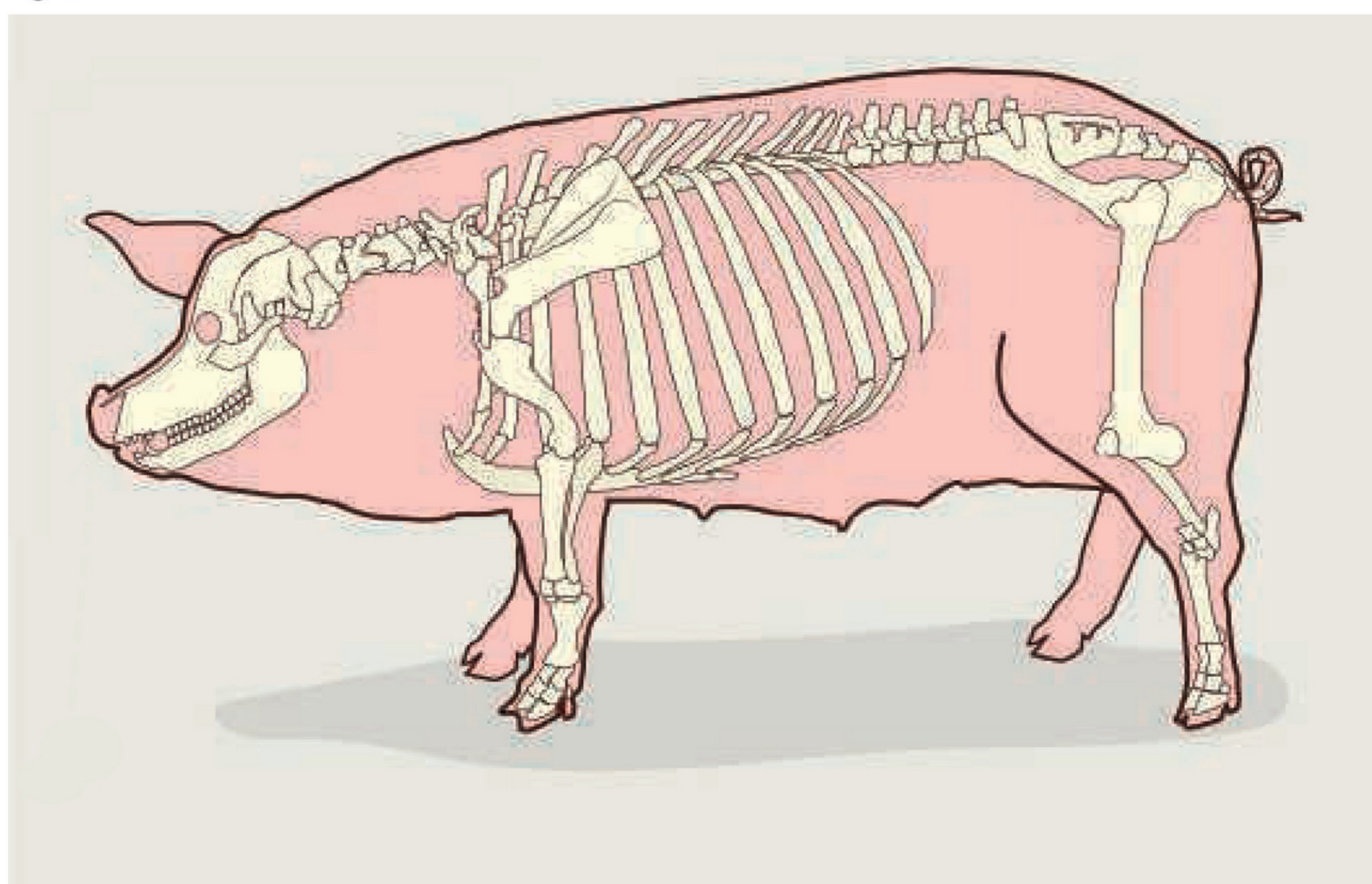
Study figure 1.1. The truffle hunter is using a stick to prevent the pig from eating the truffles.

- a Which of the pig's senses is stimulated by the hunter's stick?
- b Is detecting truffles innate or learned behaviour in pigs? And what about dogs? Explain your answer.
- c Colour in the central nervous system of the pig in figure 2.
- d When a sow smells a truffle under the ground, she walks towards it and starts salivating.



Use arrows to draw the stimuli and impulses in the body of the pig during this response in figure 2. Use two colours, one for stimuli and one for impulses.

fig. 2



2

People used to use pigs to find truffles.

Compare the senses of a human to those of a pig.

- a Which of the two is better at perceiving?
Humans can see *better / less well* and smell *better / less well* than pigs.
- b Which sense in humans plays the biggest part in tasting truffles? Explain your answer.
- c It is possible to find truffles without using dogs or pigs. If you see a bare patch in the grass under the trunk of an oak tree, there might be a truffle underneath.
Explain why a bare patch could be a sign of a truffle growing there.
- d The mycelium thread of truffles attach themselves to the tree roots. The truffles take in nutrients from the soil and pass them on to the tree. The tree also provides something to the truffle.
What does the tree provide to the truffle? Explain your answer.
- e Scientists have discovered that trees can communicate with each other via long mycelium threads. They release substance and the fungi transport them to other trees.
What can you compare this method of communication to: with passing impulses through the nerves, or with the transportation of substances via blood vessels? Explain your answer.

3

When a sow finds a truffle, she starts to salivate (drool). The truffle hunter quickly grabs the truffle before the sow eats it.

- a** The sow's reaction is a *voluntary action / reflex*. The truffle hunter's reaction is a *voluntary action / reflex*.
- b** Which reflex normally occurs when the sow bites the truffle hunter's hand?
- c** It is possible that the hunter will keep holding on to the truffle even when the sow bites.
What is the hunter's motivation for this?
- d** The hunter can apparently suppress his reflexes.
Explain what happens in the body then.

4

When a dog has found a truffle, it gets a reward. It only gets it after the truffle has been dug up.

- a** Why does the dog only get a reward after the truffle has been dug up and not before?
Use the following words in your answer: *behaviour – internal stimulus – motivation – external stimulus*.
- b** When a dog goes to find truffles, it often follows a chain of behaviour.
Describe a possible chain of behaviour in a dog that is looking for truffles and finds one.
- c** A truffle hunter sees his dog jumping around near a rabbit hole.
What is the truffle hunter's observation and what might be the interpretation?
- d** Some people steal or poison truffle dogs.
What values is their behaviour based on?
- e** What norms are these people breaking? Write down two.

5

Searching for truffles is an adventurous activity. It produces adrenaline in the truffle hunters.

- a** What is the function of adrenaline in hunters?
- b** The odour that boars (male pigs) spread is produced in the testes and eventually ends up in their saliva.
Is this scent a hormone? Explain your answer.
- c** Is a boar spreading scent an example of behaviour? Explain your answer.
- d** Is a truffle spreading its scent by signal? Explain your answer.

7 Senses and impulses

LEARNING OBJECTIVES

- 5.7.16 You can explain when senses convert stimuli into nerve impulses.
- 5.7.17 You can name the structure and function of three types of nerve cells.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES	
	5.7.16	5.7.17
Remembering		
Understanding	1	5
Using	2, 3, 4	6
Analysing		

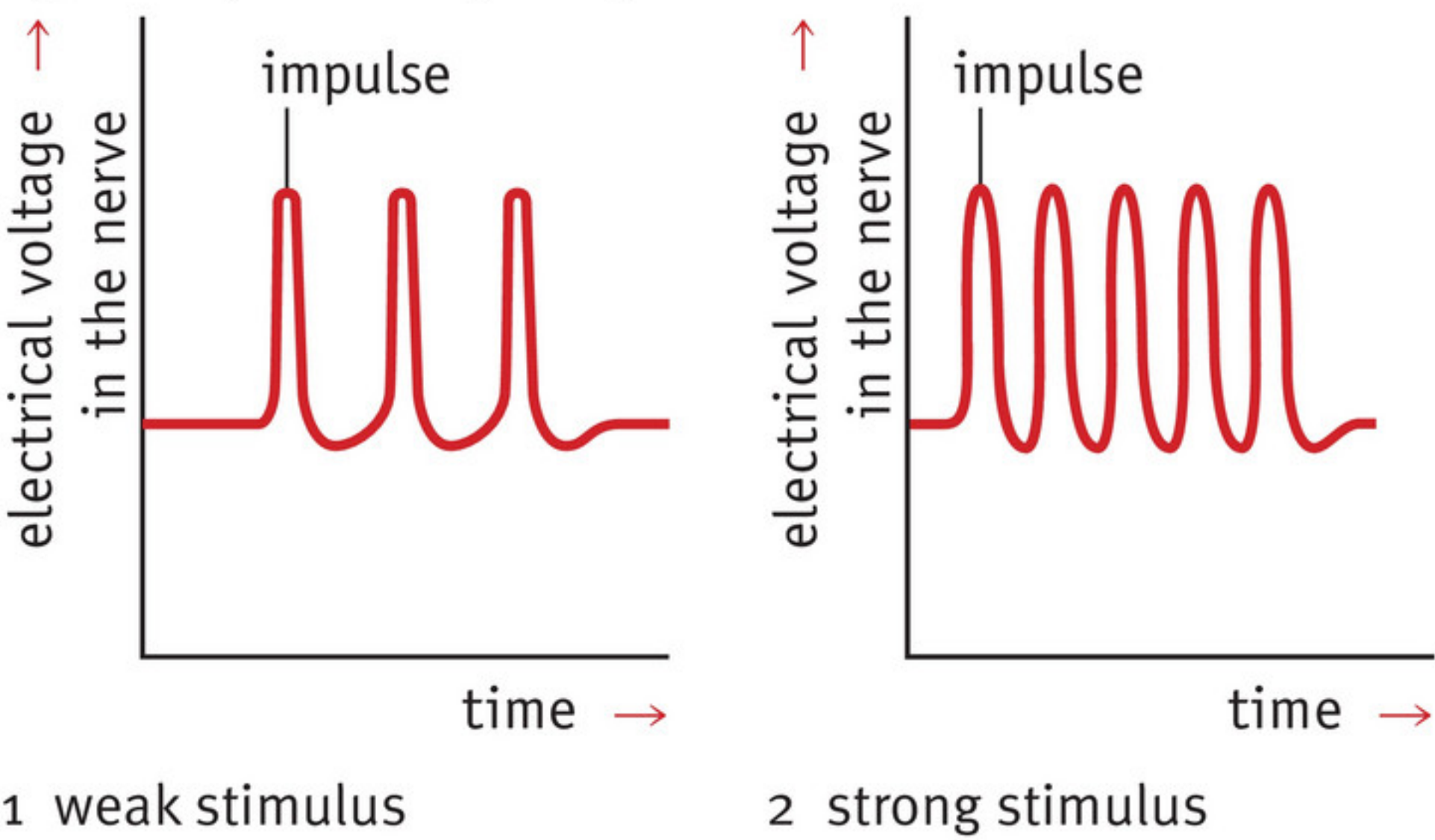
When you respond to your environment, your senses work together with your nervous system and your muscular system. Different types of nerve cells conduct the impulses from and to the brain.

HOW IMPULSES START

Impulses are only produced in sensory cells if a stimulus is strong enough. The lowest intensity of the stimulus that can cause an impulse is called the **threshold value**. If a stimulus is weaker than the threshold value, impulses will not be produced in the sensory cells. You will not hear a very soft sound, for instance.

A stimulus must first reach the threshold value. If the stimulus then gets even stronger, the **impulse frequency** increases: more impulses are sent every second. The strength of the signal – the amplitude – is always the same in an impulse (see figure 1).

fig. 1 Impulse frequency.



Each type of sensory cell has a specific threshold value for each type of stimulus. The threshold value of sensory cells in your eyes is very low for light stimuli. As a result, the sensory cells in your eyes are particularly sensitive to light. We therefore call light the **adequate stimulus** for the sensory cells in your eyes. An adequate stimulus is the type of stimulus that a sensory cell is particularly sensitive to. The sensory cell has a low threshold value for this stimulus.

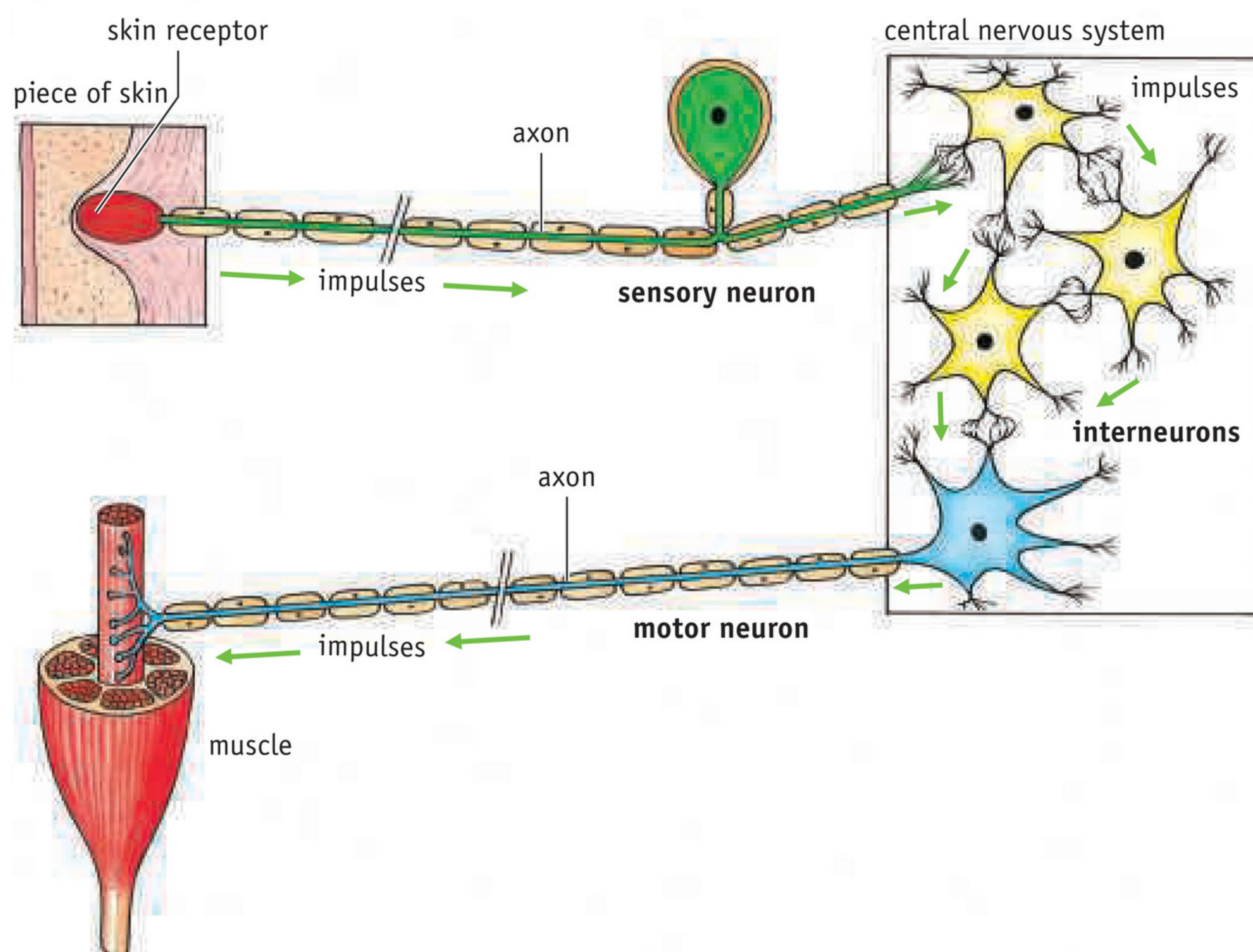
Each type of sensory cell has its own specific adequate stimulus. However, sensory cells can also perceive other, non-adequate stimuli. The threshold value for these non-adequate stimuli is much higher, though. If you close your eyes and press your eyelids gently with your fingers, for instance, you will see nothing. The stimulus is lower than the threshold value. But if you get hit hard on your eyes, you will ‘see stars’. The blow produces impulses in the eyes, These impulses are passed to the brain and are interpreted as seeing stars.

The threshold value for a stimulus is not always the same. After an earlier strong stimulus, the threshold value gets higher. After spending some time in bright light, you cannot see much when you first go outside at dusk. You only see as you normally do after adjusting for a few minutes. If a stimulus does not go away for some while, it starts producing fewer impulses in the sensory cells. This is called **habituation**. Because of habituation, you do not feel the pressure of your clothing on your body after a little while, for instance. The threshold value has increased.

THREE TYPES OF NERVE CELLS

Figure 2 shows you three types of nerve cells: sensory neurons, motor neurons and interneurons.

fig. 2 Three types of nerve cells.



Sensory neurons pass the impulses from the sense organs to the central nervous system. The cell bodies of sensory neurons are near the central nervous system. A sensory neuron has a single long axon, which passes impulses towards the cell body. Sometimes this axon can be as much as a metre long, for instance in a sensory neuron that passes impulses from a sensory cell in the toe to the cell body near the spinal cord.

Motor neurons pass impulses from the central nervous system to muscles or glands. The cell bodies of motor neurons are in the central nervous system. A motor neuron has a single long axon (sometimes up to a metre long) that passes impulses away from the cell body.

Interneurons conduct impulses within the central nervous system. They connect the axons of sensory neurons to the axons of motor neurons. Interneurons are located entirely within the central nervous system. Interneurons are connected to each other by axons.

EXERCISES

1

- a** Which sensory cell is more sensitive to a particular stimulus?
a sensory cell that has a *high* / *low* threshold value for that stimulus
- b** Whose smell receptors have the lower threshold value for odours?
a *dog's* / *human's*

2

Three light stimuli (A, B and C) of different intensities are shone at Pat's eye. The diagram in figure 3 shows these light signals.

The impulses are conducted from her eye to her brain along a nerve. Figure 4 shows the electrical activity of part of that nerve in three diagrams, P, Q and R.

- a** Which diagram belongs to which light stimulus?
Light stimulus A belongs with diagram *P* / *Q* / *R*.
Light stimulus B belongs with diagram *P* / *Q* / *R*.
Light stimulus C belongs with diagram *P* / *Q* / *R*.
- b** How high is the impulse frequency for each light stimulus?
light stimulus A *o* / *high* / *low*
light stimulus B *o* / *high* / *low*
light stimulus C *o* / *high* / *low*

fig. 3

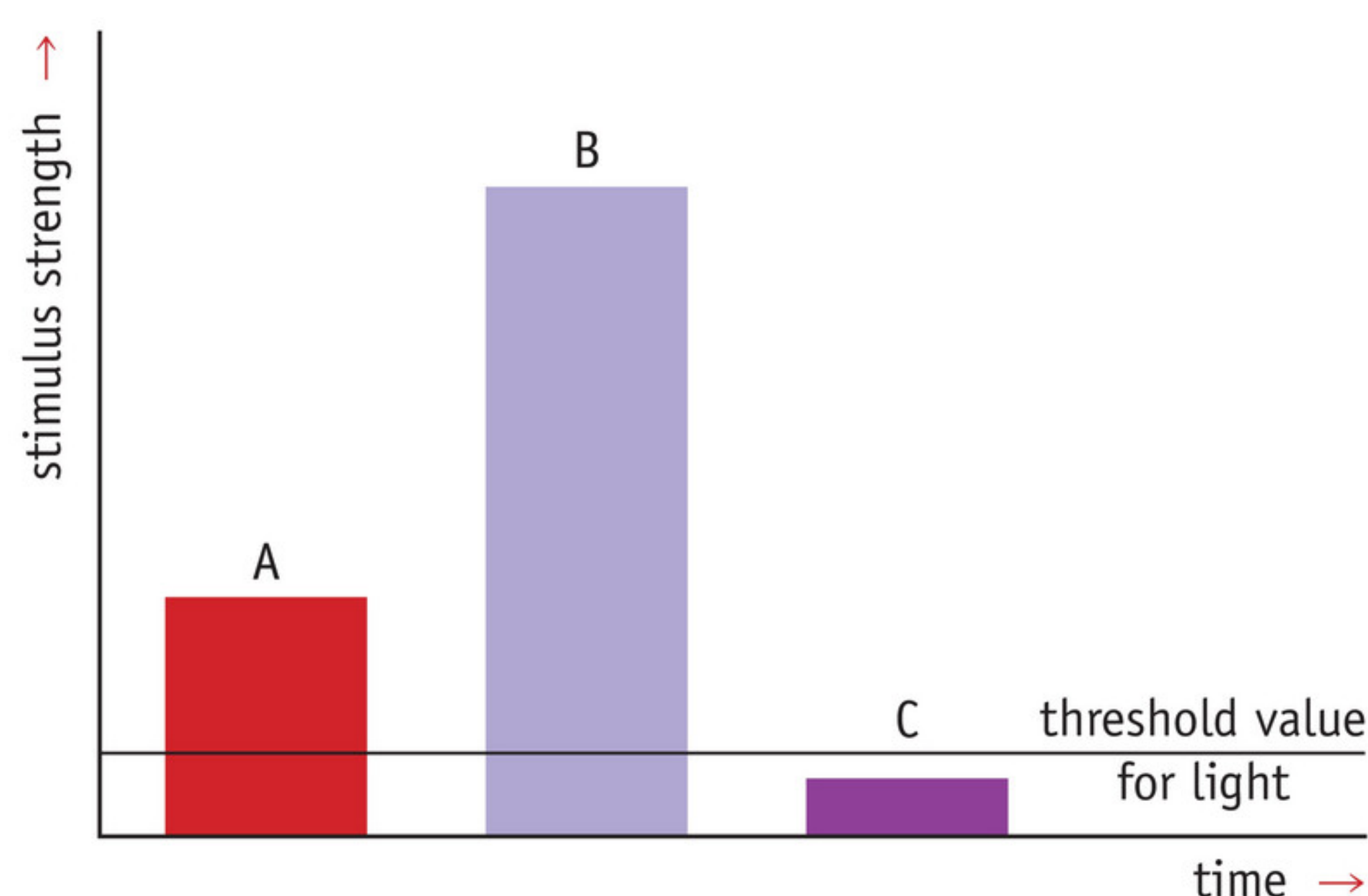
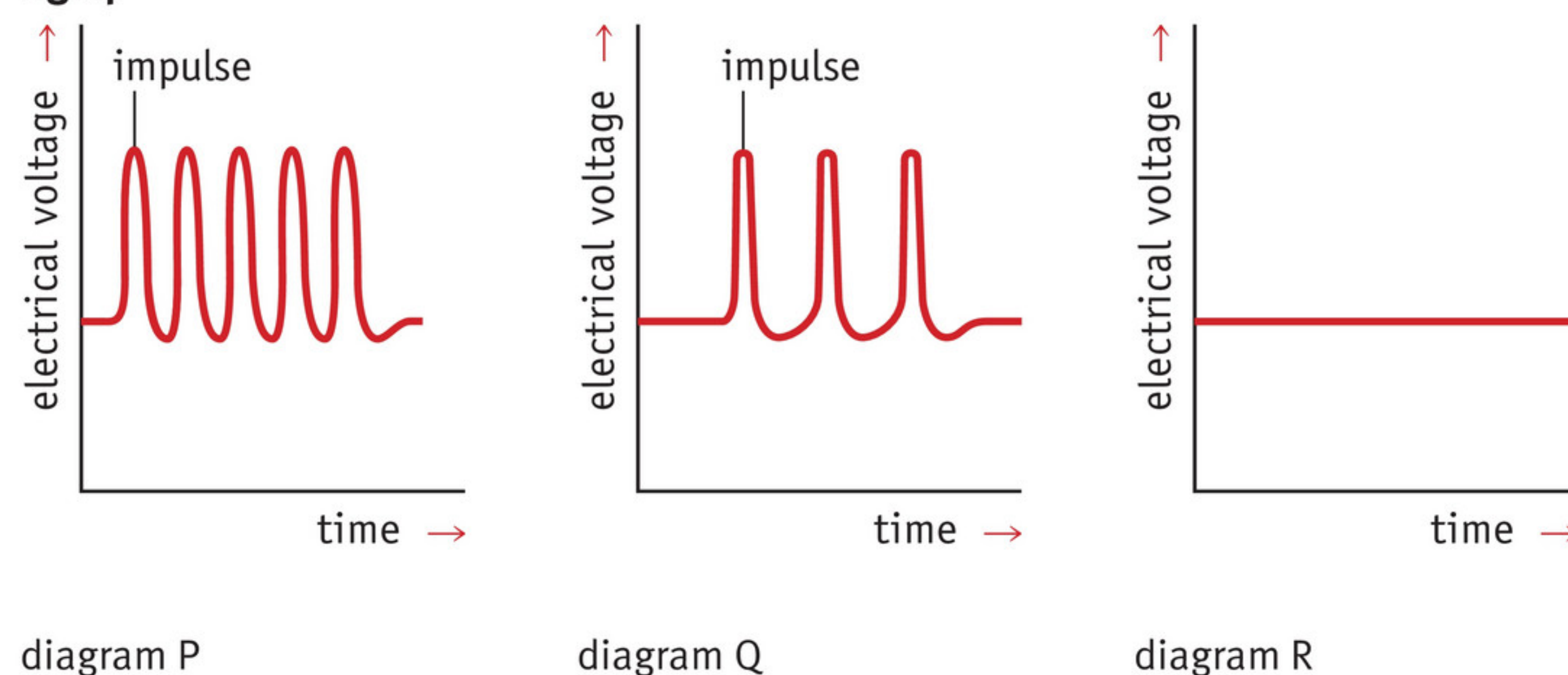


fig. 4



3

Read the text ‘Taser paralyses suspect’ in figure 5.
Why can a suspect who has been tasered no longer move?

fig. 5

Taser paralyses suspect

The arrest teams of the civil and military police sometimes use tasers as weapons. The taser paralyses a suspect with an electric shock. A policeman aims a laser at the suspect and pulls the trigger, after which two darts are shot into the suspect’s body. These darts have small barbs. The suspect then gets several electric shocks. These block the electrical signals through the nerves, making the suspect fall down paralysed.



4

A coin is placed on a person’s hand. They feel this immediately and looks at the coin.
a Does this perception involve impulses passing through the central nervous system?
Explain your answer.
b After a time, the sensation of the coin’s pressure disappears for this person.
What is the name for this effect?

5

Complete the table.
• For 1, use: *to the central nervous system – from the central nervous system*
• For 2, use: *from interneurons – from sensory cells*
• For 3, use: *to interneurons – to muscle cells or gland cells*
• For 4, use: *in the nervous system – near the central nervous system*

Question	Sensory neurons	Motor neurons
1 Which direction do they conduct the impulses in?		
2 What type of cells do they receive the impulses from?		
3 What type of cells do they conduct the impulses to?		
4 Where are the cell bodies?		

6

Read the article “Losing weight with an electrode in the brain” in figure 6 and the article “Test with an intelligent wheelchair” in figure 7.

Which types of nerve cells (or parts) are being taken over?

- 1 Certain parts of the brain regulate our sense of feeling full. By turning on the electrode, these parts get an artificial signal that the body has eaten enough.
motor neurons / sensory neurons / interneurons
- 2 The correct signals in the brain of the operator are picked up by sensors in the bathing cap and converted by the electronics in the wheelchair into the commands for forward, left and right.
motor neurons / sensory neurons / interneurons
- 3 The wheelchair also has sensors that can measure whether it is too close to an object. If so, the wheelchair is stopped or its direction adjusted to prevent collisions.
motor neurons / sensory neurons / interneurons

fig. 6

Losing weight with an electrode in the brain

Scientists at Antwerp University Hospital and KUL in Louvain are doing an experiment to help severely obese patients lose weight. They are doing it by inserting electrodes in the brain.

Certain parts of the brain regulate our sense of satiety (whether we are full). By turning on the electrode, these parts get an artificial signal that the body has eaten enough. One of the test subjects says, “Before the operation, I could just keep eating. I never really felt I’d had enough, or when I did it took a lot. Now I feel full after one plateful, like most people. Before, I only felt like that if I ate very greasy food.”

fig. 7

Test with an intelligent wheelchair

BRUSSELS – In recent months, KUL in Louvain (Belgium) has carried out successful tests with an intelligent wheelchair. The wheelchair is special because it is controlled by the user’s brain signals. If the user thinks they want to move forward, left or right, the wheelchair will actually go in that direction. This is possible because the brain signals are captured via a sensor cap. This is like a kind of bathing cap with electrodes that is placed over the user’s scalp. The relevant signals in the operator’s brain are picked up by sensors in the bathing cap and converted by the electronics in the wheelchair into the commands for forward, left and right. The wheelchair also has sensors that can measure whether the wheelchair is too close to an object. If so, the wheelchair is stopped or its direction adjusted to prevent collisions. The intelligent wheelchair is a solution for people who are not able to manoeuvre the wheelchair with their hands.



 Go to the *Flash cards*.

8

Hearing damage

LEARNING OBJECTIVE

5.8.18 You can explain that loud noise can cause hearing damage.

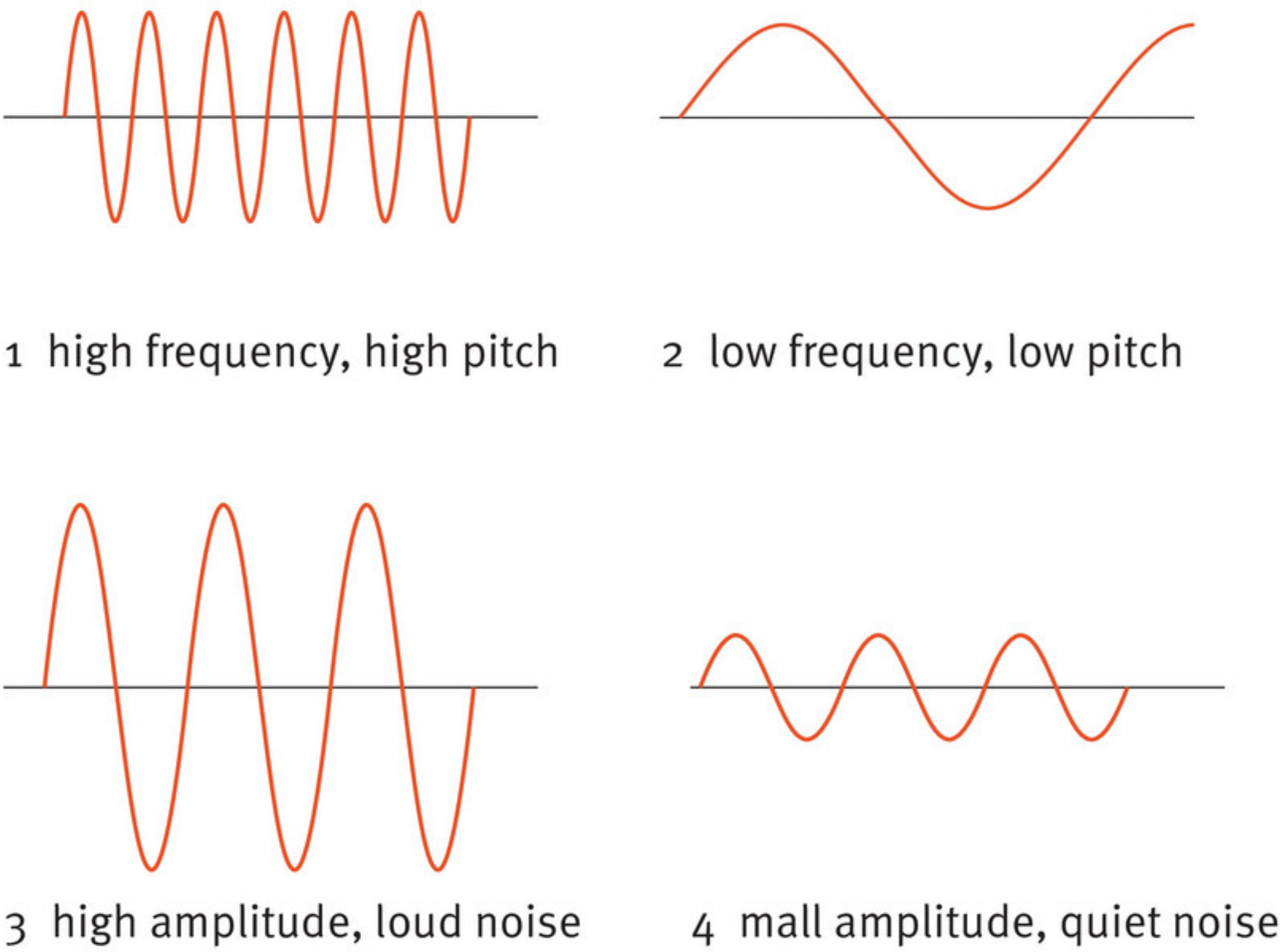
TAXONOMY	LEARNING OBJECTIVE AND EXERCISES
	5.8.18
Remembering	
Understanding	1, 2a
Using	3, 4, 5ac
Analysing	2b, 5b

Almost one in four young people gets hearing damage. The reason is that they listen to loud noise for too long. You can prevent hearing damage.

SOUND

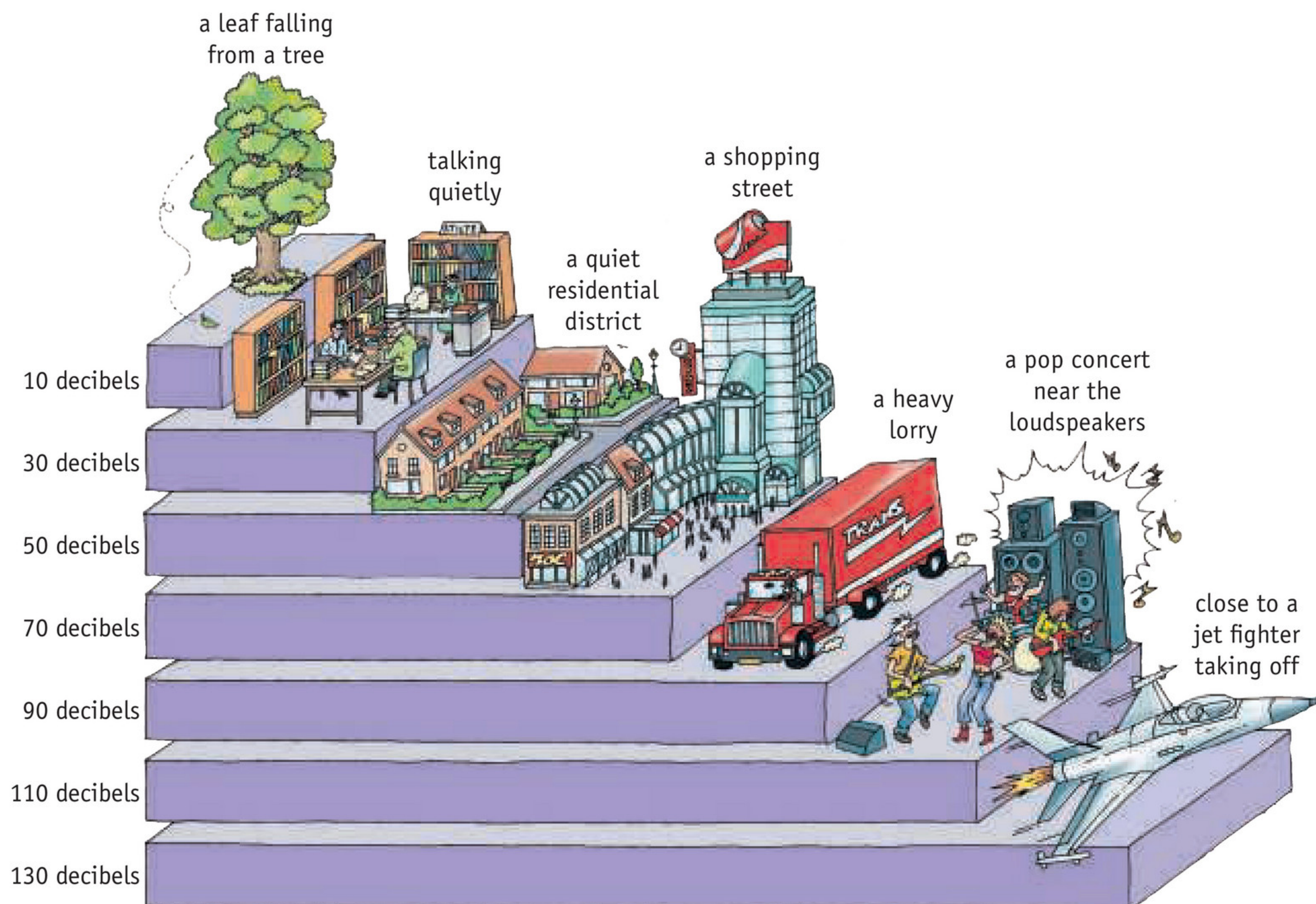
Your auditory receptors let you perceive sounds. Sound are vibrations in the air. When the air is vibrating quickly, the sounds you hear are high-pitched (see figure 1). The **sound frequency** is high. If the air vibrates slowly, the sound frequency and the pitch are low. The sound frequency is expressed in **hertz** (Hz). If the vibrations have a high **amplitude** (move the air a lot), the sound will be loud. If the vibrations have a small amplitude, the sound will be quiet.

fig. 1 Sounds are vibrations in the air.



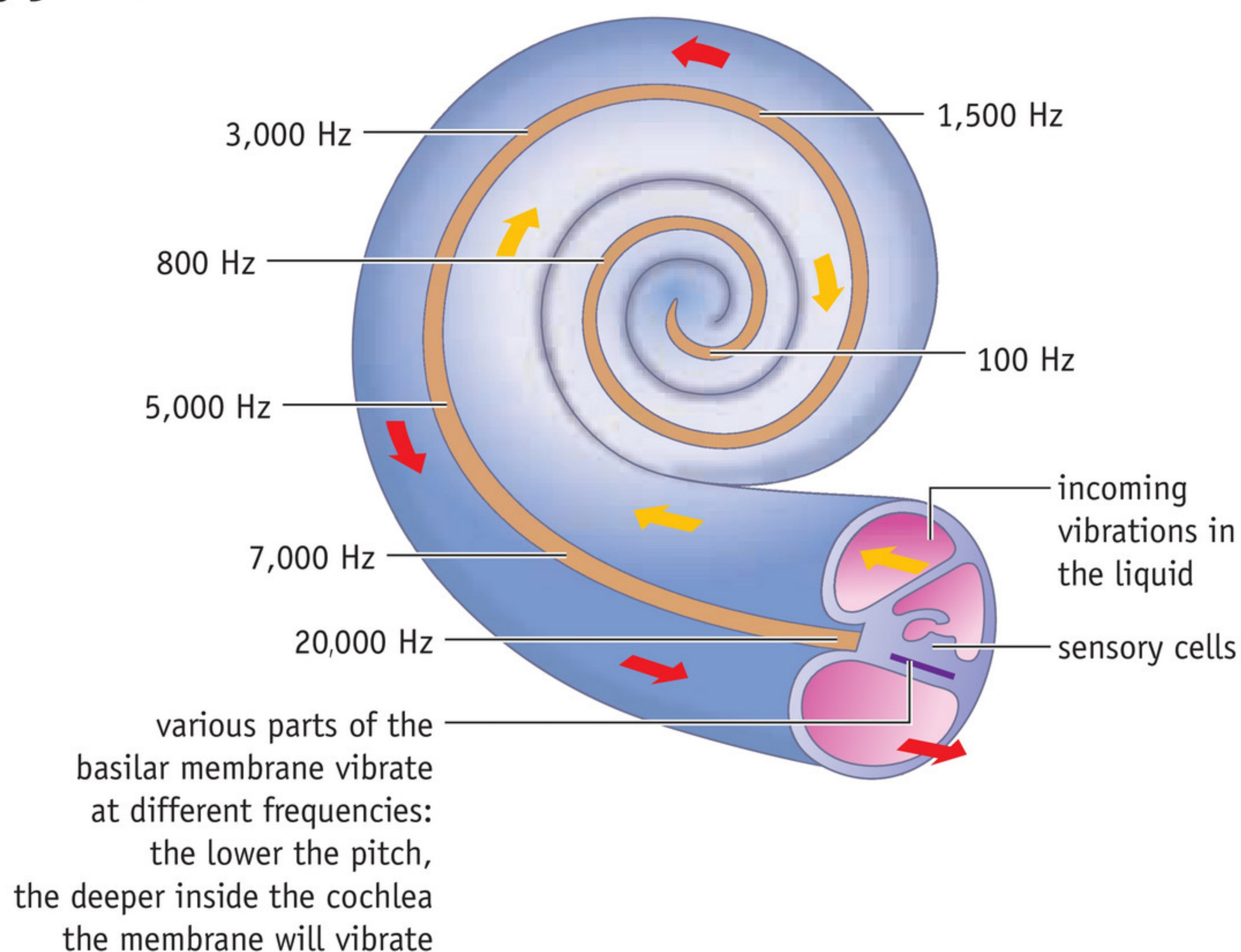
As sounds that become higher in pitch, there will be a certain moment that you will not be able to hear them. What pitches you are only just able to hear also depends on your age. As you grow older, you will be increasingly less able to hear high-pitched tones.

The **volume** (the loudness) of a sound is expressed in **decibels** (dB). Figure 2 shows a scale of noise levels. Sounds from 80 dB upwards can cause hearing damage if you listen to them too often and for too long. You will then have more and more trouble hearing. In the long run, you may even go deaf. Sounds from 130 dB upwards cause severe earache.

fig. 2 A scale of noise levels in decibels.

THE COCHLEA

The cochlea consists of three chambers that are rolled up into a spiral. All three chambers are filled with a liquid. One of these chambers starts at the membrane (the 'oval window') that is connected to the stirrup. If the ossicles make the window vibrate, the liquid in the chambers of the cochlea starts to vibrate too. The vibrations of these liquids are passed on to the **basilar membrane**. For each sound frequency, a specific part of the basilar membrane starts vibrating (see figure 3).

fig. 3 Vibrations of the basilar membrane.

The middle of the three ducts contains sensory cells. They are stimulated by the vibrations of the basilar membrane. The sensory cells are connected to the auditory nerve, which transmits the impulses to the brain. Different sensory cells release impulses to the auditory nerve for high-frequency sounds than for low pitches. This lets you perceive different pitches.

HEARING DAMAGE

About 20% of young people aged 12 to 25 have hearing loss. This means that they can hear less well. Loud noises in the ears for too long damages the cilia in the cochlea. These cilia are parts of the sensory cells. They pick up sounds, which the sensory cells then convert into impulses and pass on to the brain. If the cilia are damaged, the sense of hearing no longer works properly. A constant ringing in the ears (tinnitus) is also common.

Most young people are aware that they run a risk of getting hearing damage if they are exposed to noise for too long at concerts or in clubs. Your phone's earphones can be a big risk too. Young people listen to music frequently and for long periods on earphones or headphones, often with the volume set to the maximum. The **duration of exposure** to noise at above 80 dB has therefore increased enormously (see figure 4). Since 2013, music players have been required to have volume limiters, and you will see a message when you set the volume to more than 85 dB.

The problem is that you probably know that loud music isn't good, but don't notice the consequences immediately. Hearing damage is cumulative, building up slowly. A lot of young people therefore never take precautions to prevent or reduce hearing damage, although they are aware of these dangers. Once you have hearing damage, you have to wear hearing aids. To prevent hearing damage: not too loud, not too long and use hearing protection (muffling earplugs) if needed.

If you think you have hearing damage, you can have it checked by your GP (see figure 5).

fig. 4 Duration of exposure.

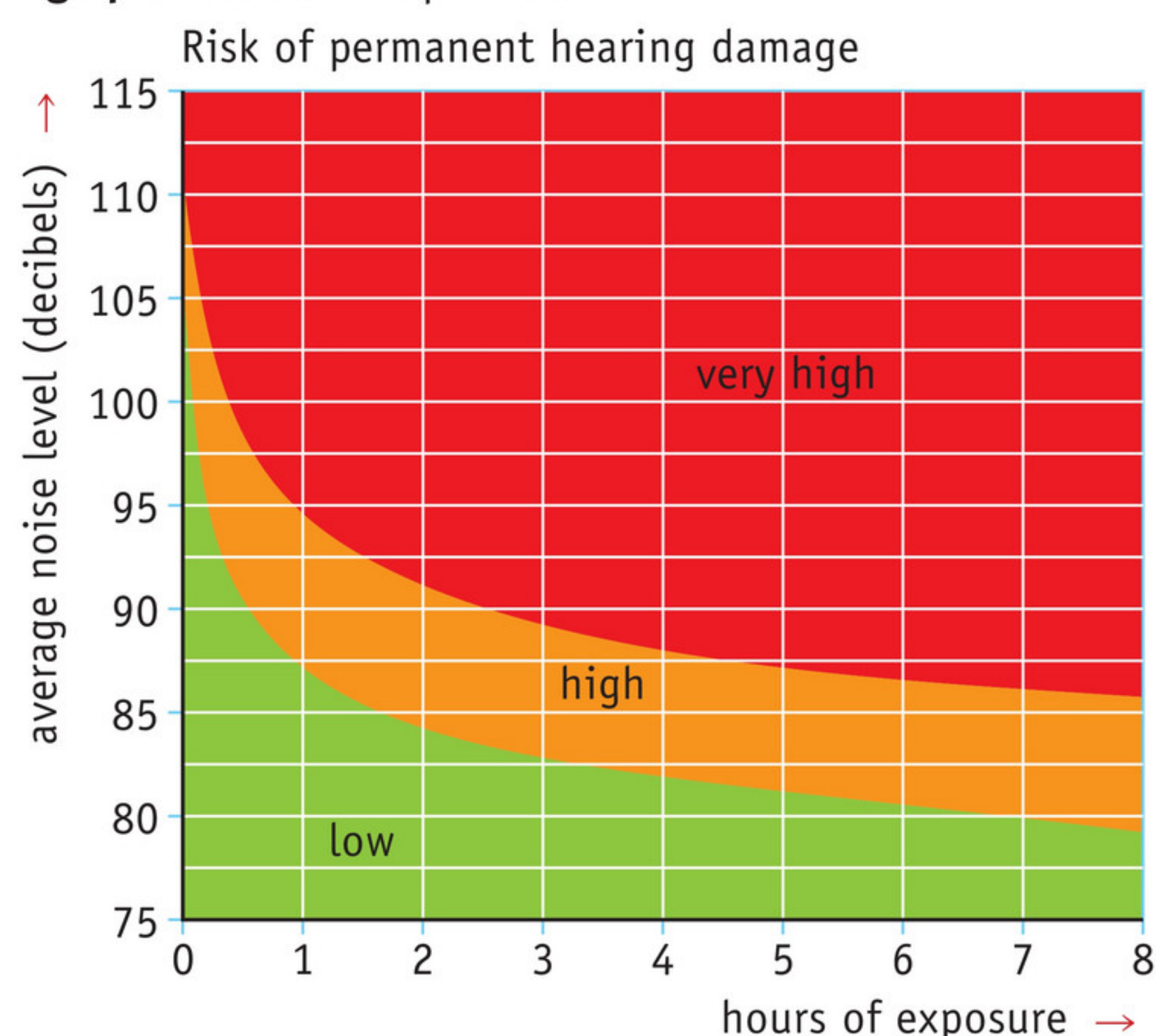


fig. 5 Checking the ear.



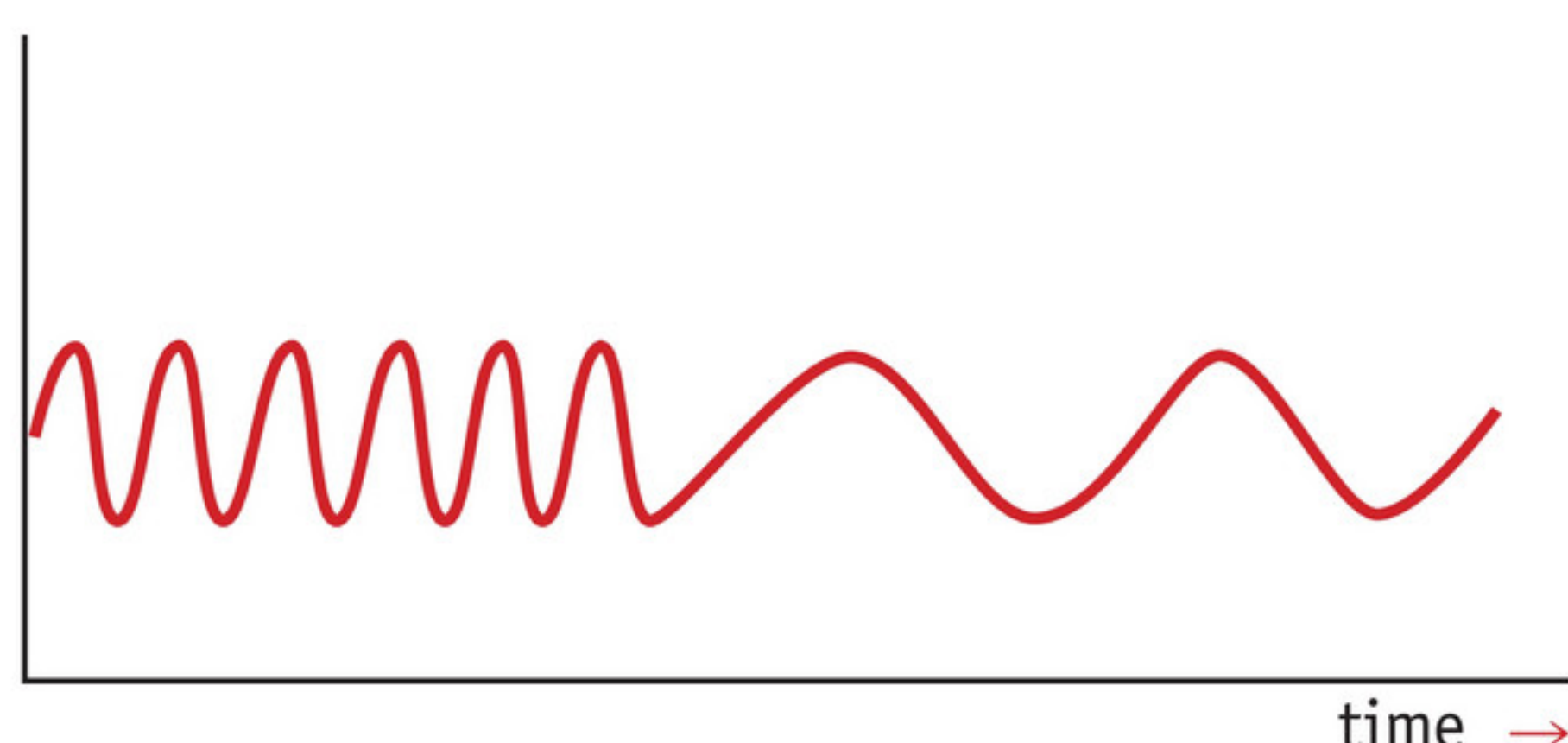
EXERCISES

1

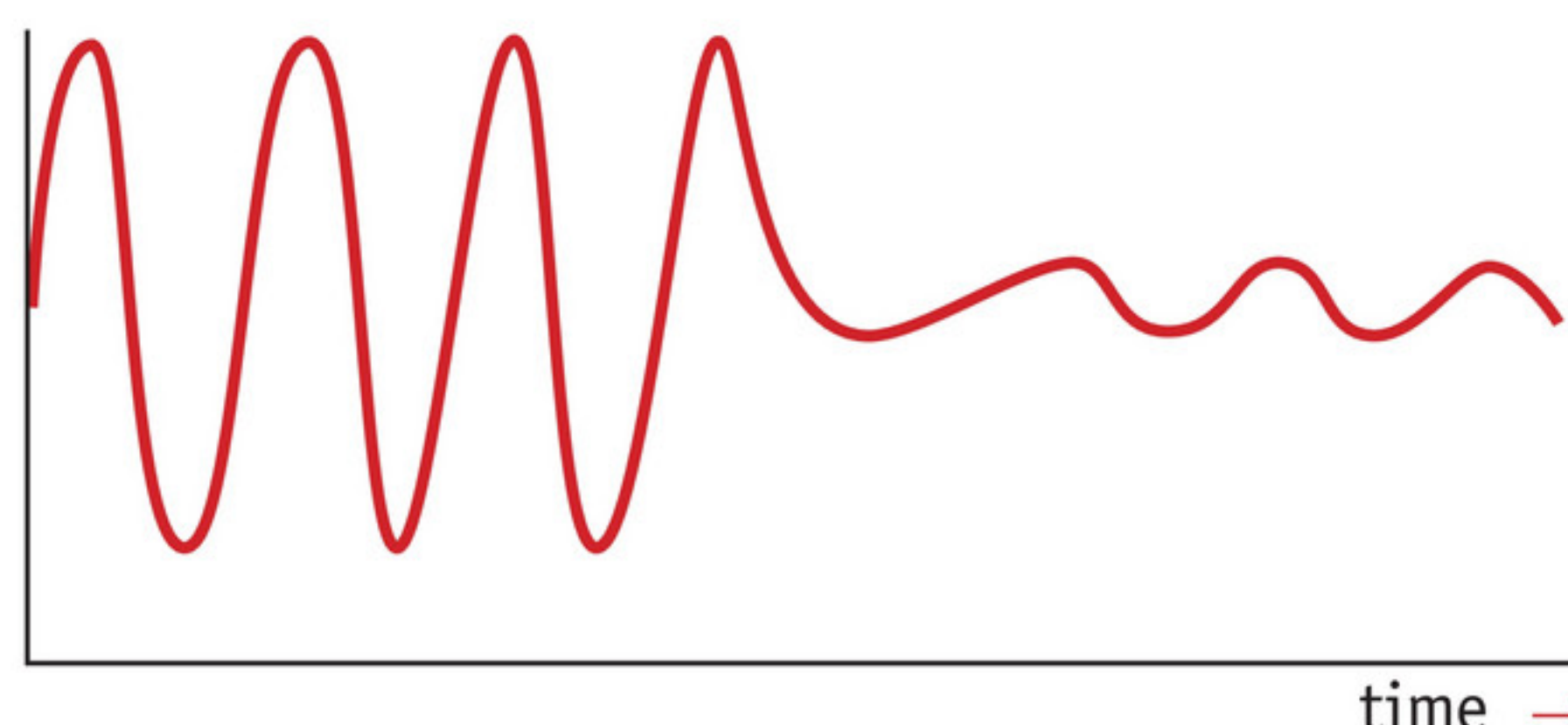
Figure 6.1 shows the vibration of a sound.

- a How is this sound changing?
- b How is the sound changing in figure 6.2?

fig. 6



1



2

2

Read the text 'Mosquito drives off problem youngsters' in figure 7.

- a How can you tell that your hearing deteriorates as you get older?
- b Why does habituation not occur to the mosquito sound ?

fig. 7

Mosquito drives off problem youngsters

NIJMEGEN – Various municipalities are using the Mosquito as a last resort against young people who are hanging around and being a nuisance. The Mosquito is a device that continuously emits varying high-pitched tones of between 16 and 19 kHz (kilohertz). These high pitches are often very irritating to young people, but most people over the age of 25 cannot hear them anymore.

From age 25 you can hear up to about 15 to 16 kHz. From age 30 to 50 you can hear sounds up to 14 kHz, from age 50 up to 12 kHz, and it keeps decreasing further with age.

The Mosquitoes are usually only turned on after 8 p.m. because young children can hear sounds up to 24 kHz. The devices seem to be working well, although there is some criticism. Sometimes the youngsters simply move to a different place and cause problems there. And some young people who are hanging around aren't causing trouble, but they can still hear the annoying sound.



3

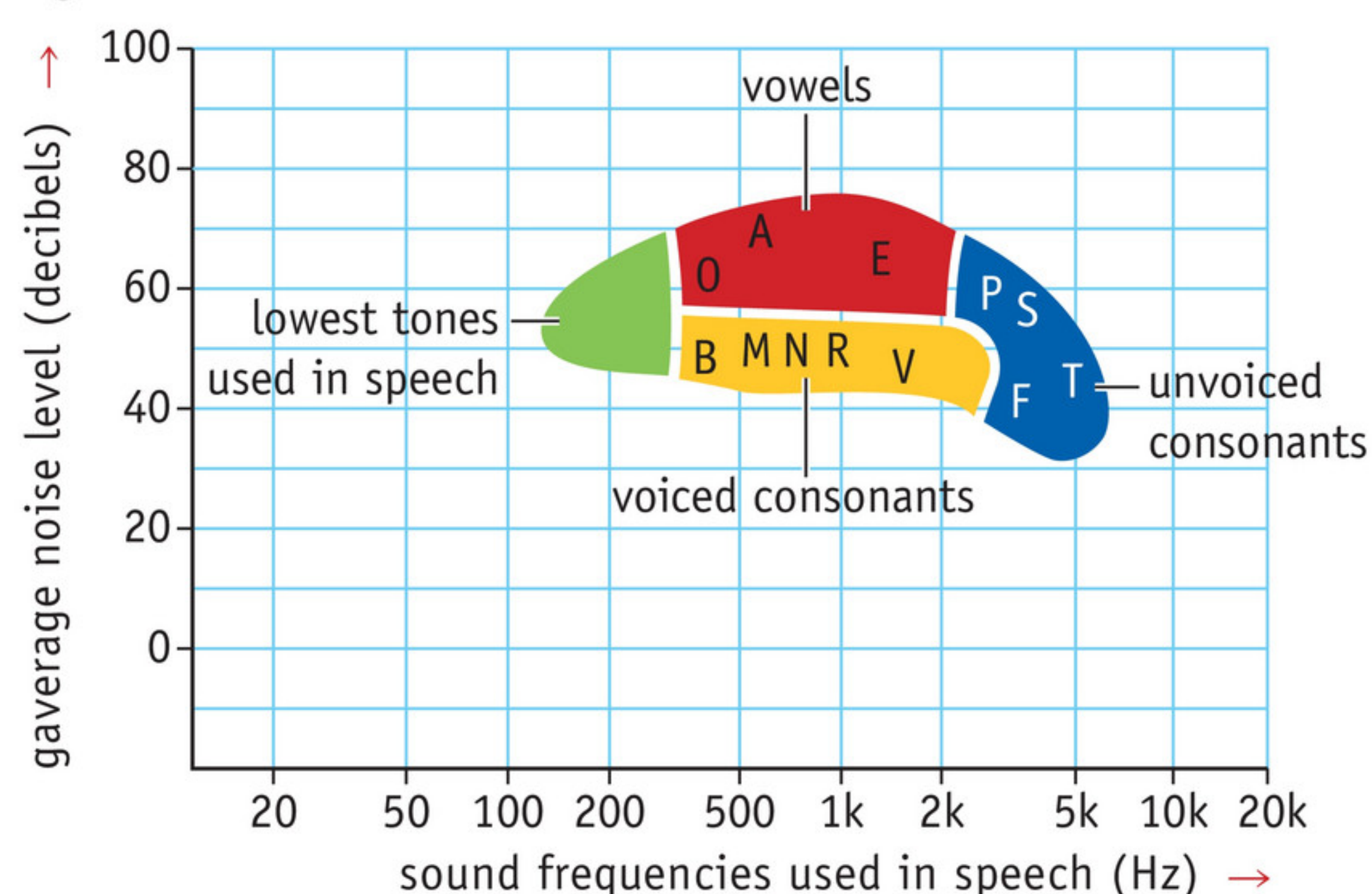
When the sound level is above 85 dB, the volume limiter on music players gives a warning. A pupil says, "I always have my music player as loud as possible without getting any warnings. That means I'm never running any risk of hearing damage." Explain why this statement is incorrect.

4

Letters for different sounds in the spoken range can be divided into three groups (see figure 8).

The left ear of someone with hearing loss is being tested. The test shows that this person cannot hear tones above 2000 Hz very well. What words is this person probably not able to distinguish with their left ear: map and nap or sap and tap? Explain your answer.

fig. 8



5

Read the text about a 'Cochlear implant' in figure 9.

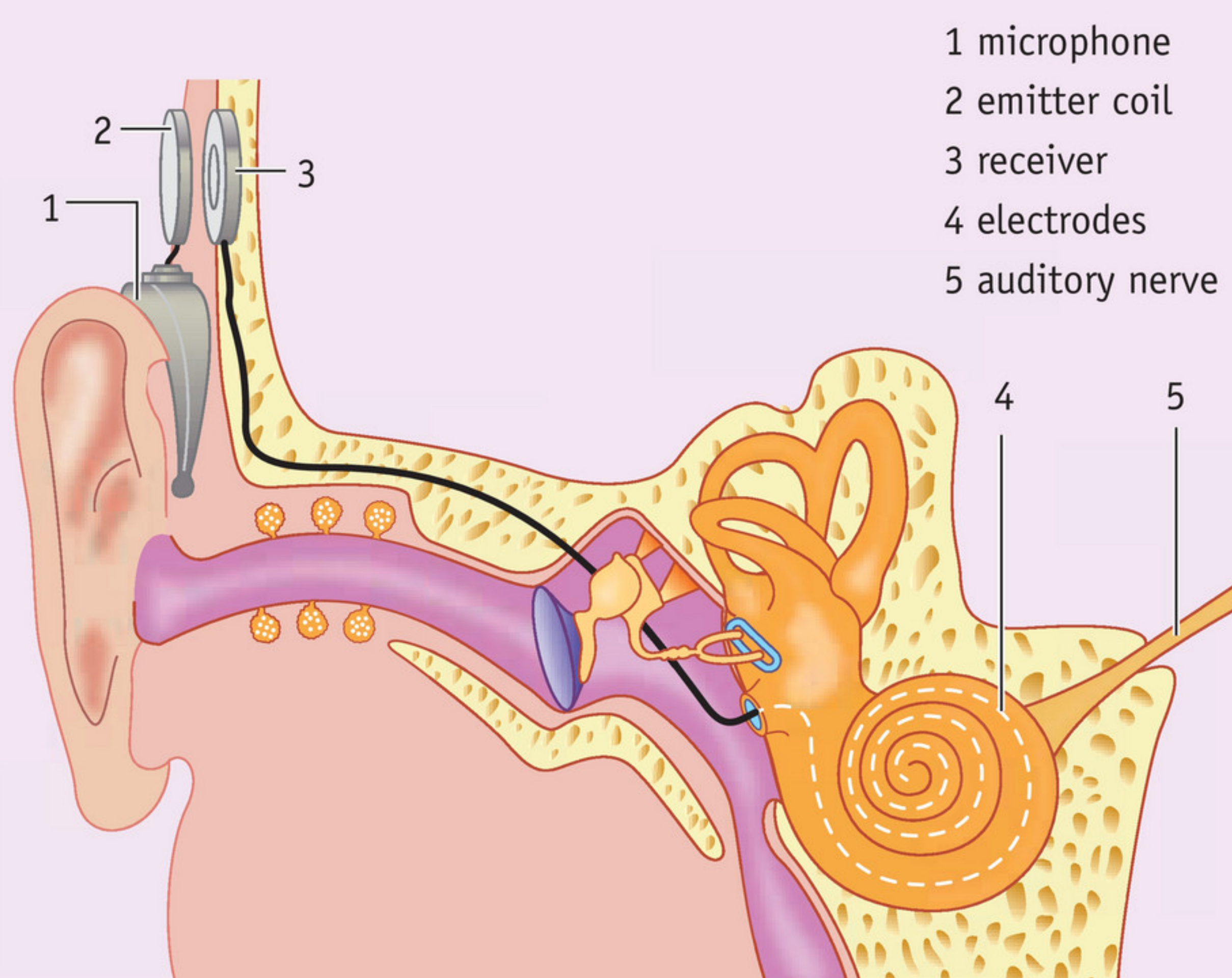
- Which part of a cochlear implant replaces the auditory sensory cells? Explain your answer.
- A cochlear implant lets deaf people hear the various sound frequencies of a language. They can often then have conversations again. Explain that this only works if they had previously learned to understand a spoken language.

fig. 9

A cochlear implant

Some deaf people can hear reasonably well again after a surgery to insert a cochlear implant. The cochlear implant works as follows:

- Sounds are picked up with a microphone (1).
- The microphone transmits the sound information to the transmitter coil (2).
- The implanted receiver (3) picks up these wireless sound frequencies and converts them into electrical signals that go to a maximum of 22 electrodes (4) implanted in the cochlea.
- These electrodes, each of which is in a different part of the cochlea, stimulate the auditory nerve directly in 22 different places (5).



The person then perceives the various sound frequencies in their brain. They can often have conversations again. However, this only works if they had been able to understand the spoken language before they went deaf.

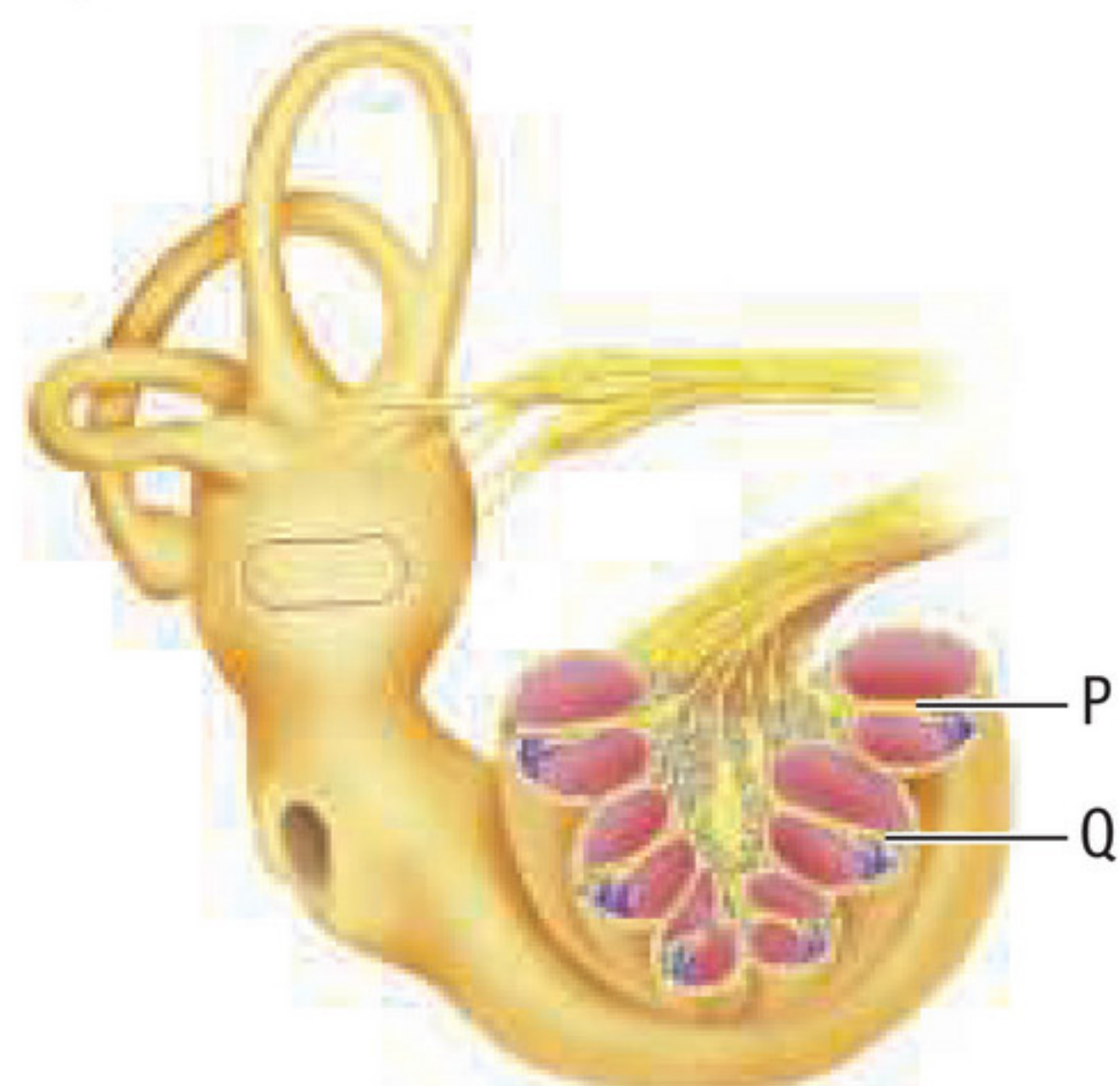
- c Use figure 8 for this question as well.

A person with a cochlear implant listens to the letters 'O' and 'T'. There are two places in figure 10 labelled P and Q. The cochlear implant's electrodes give electrical signals to the auditory nerve at these locations when 'hearing' the letters O and T.

When the letter O is heard, an electrical signal is given at location P / Q.

When the letter T is heard, an electrical signal is given at location P / Q.

fig. 10



 Go to the *Flash cards*.

Learning how to do research

1

STUDY QUESTION AND HYPOTHESIS

► Basics 1 | ► Learning objectives 5.O.19 and 5.O.20 | ► Practical activities 1, 2, 3 and 4

STUDY QUESTION

Research starts with a study question: the question you want to answer with your study. A situation, a problem or simple curiosity is usually what leads to a study question. If you come up with a study question yourself, try thinking up a study as well that might be able to answer that question. If the work plan has been given, formulate your study question so that you can answer it using the results from the study.

HYPOTHESIS

You formulate a hypothesis before you begin your study. The hypothesis is your provisional answer to the study question. Consider why you think that might be the answer. Do not just make something up.

You test your hypothesis by conducting the study. That is why a hypothesis can help you design a work plan. If a work plan has already been given, you formulate your hypothesis in a way that lets you test it by following the work plan.

EXERCISES

1

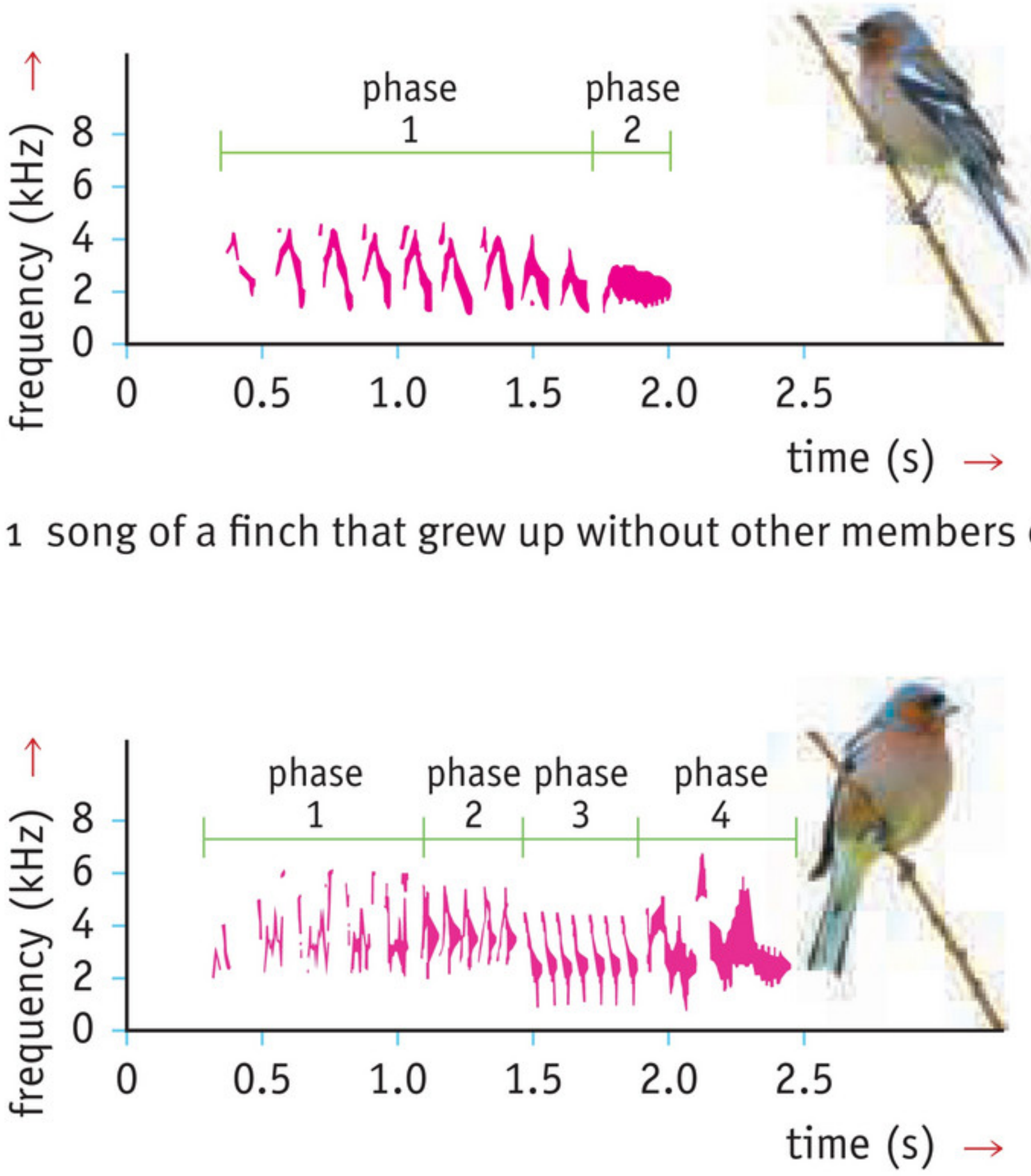
Luke has a chicken coop in his back garden. During the day, the chickens and the rooster often roam around the back garden, looking for chicken feed that is lying around. When Luke looks at the chickens pecking, he wonders where this behaviour comes from. His mother thinks that pecking for food comes naturally to chickens and is therefore inherited behaviour, but his father is convinced that it is learned behaviour. Luke decides to investigate which of his parents is right.

- a** What is Luke's study question?
- b** What do you think the answer to this study question is?
- c** Explain in one or two sentences why you think so.
- d** Luke incubates an egg in the attic. When the chick is born, Luke gives it chicken feed for the first time. The chick has never seen any other chickens, but as soon as it notices the chicken feed, it starts pecking at it. Luke repeats this four times. Each time, he sees how the newly hatched chick immediately starts pecking at the bird feed.

What conclusion can Luke draw?

2

- The English biologist William Thorpe noticed that the songs of finches in different areas have similarities, but can also differ from region to region. He wondered if the finches’ song is innate, learned or a bit of both.
- a What is Thorpe’s study question? Write it down in the table.
 - b Formulate a hypothesis for this study question. Explain in one or two sentences why you think that this is the answer to the study question.
 - c The table shows the experiment that Thorpe conducted. Study the results and write down your conclusion in the table.

RESEARCH	FINCH SONGS
Study question	
Hypothesis	
Work plan	Newly hatched finches are placed in a soundproof room and raised by hand. The young finches do not hear members of their species singing. When these isolated young birds start to sing, their songs are recorded in a graph. This is compared to the graphs for finches in the wild.
Results	The isolated finches start singing after a while, but the finch song does not vary much (two phases). Finches in the wild make a lot more different sounds when they sing (four phases). Sometimes these phases are even more varied (see figure 1). Fig. 1  1 song of a finch that grew up without other members of its species 2 song of a finch that grew up with other members of its species
Conclusion	

2

BEHAVIOURAL STUDY

► Basics 5 | ► Learning objective 5.O.21 | ► Practical activity 7

Animal behaviour is usually studied in the wild because animals in the wild show their natural behaviour. Animals behave differently in captivity. To study animal behaviour, researchers study the behaviour, note the time the animals spend on certain behaviours and indicate what order these behaviours happen in. They do not note down interpretations, only observations. The term for the study of behaviour is **ethology**.

Behavioural biologists also formulate a study question and a hypothesis. Before they start the study, they make a list of the actions that they want to observe. A description of the animal’s actions is called an **ethogram** (see figure 2). In an ethogram, you only note down the actions that are needed to answer the study question. Someone who wants to investigate how much time a cat spends grooming its fur, only notes down actions to do with that, such as licking its fur and cleaning its head with a (wet) front paw.

fig. 2

Ethogram																			
Aim	To make a list of objective descriptions of the actions of an animal species.																		
Work plan	The actions of the animal that is being studied are listed. An abbreviation is defined for each action.																		
Results	<table><tr><th>Action</th><th>Abbr.</th><th>Description</th></tr><tr><td>biting</td><td>b.</td><td>gnawing on material other than food</td></tr><tr><td>drinking</td><td>dr.</td><td>licking at water from bottle or bowl</td></tr><tr><td>eating</td><td>e.</td><td>taking food in the mouth, followed by a chewing motion</td></tr><tr><td>digging</td><td>dg.</td><td>moving the front paws back and forth in the ground; the sand is sometimes pushed out behind using the back legs</td></tr><tr><td>lookout</td><td>lo.</td><td>standing upright on the back legs and...</td></tr></table>	Action	Abbr.	Description	biting	b.	gnawing on material other than food	drinking	dr.	licking at water from bottle or bowl	eating	e.	taking food in the mouth, followed by a chewing motion	digging	dg.	moving the front paws back and forth in the ground; the sand is sometimes pushed out behind using the back legs	lookout	lo.	standing upright on the back legs and...
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lookout	lo.	standing upright on the back legs and...																	

Fixed action patterns are used during the study. The **fixed action patterns** are a list of actions successively observed in the ethogram (see figure 3).

fig. 3

Fixed action patterns																																											
Aim	Actions from the ethogram which are successively observed in an animal are recorded for a given time interval.																																										
Work plan	An animal is observed for a given period of time. In a table of times, the actions observed at those specific times are written down, using the abbreviations from the ethogram.																																										
Results	<table><tr><th></th><th>1st minute</th><th>2nd minute</th><th>3rd minute</th><th>4th minute</th><th>5th minute</th></tr><tr><td>0-5 s</td><td>ph.</td><td>dg.</td><td>e.</td><td>b.</td><td>ex.</td></tr><tr><td>6-10 s</td><td>ph.</td><td>dg.</td><td>e. dr.</td><td>b.</td><td>ex. sl.</td></tr><tr><td>11-15 s</td><td>ph.</td><td>dg. sl.</td><td>dr. e.</td><td>b. sl.</td><td>sl. ex.</td></tr><tr><td>16-20 s</td><td>ph.</td><td>dg. sl.</td><td>e.</td><td>ph.</td><td>ph.</td></tr><tr><td>21-25 s</td><td>ph. r.</td><td>dg.</td><td>e.</td><td>ph.</td><td>ph.</td></tr><tr><td>26-30 s</td><td>ph. dr.</td><td>dg.</td><td>sl. lo.</td><td>ph.</td><td>ph. sl.</td></tr></table>		1st minute	2nd minute	3rd minute	4th minute	5th minute	0-5 s	ph.	dg.	e.	b.	ex.	6-10 s	ph.	dg.	e. dr.	b.	ex. sl.	11-15 s	ph.	dg. sl.	dr. e.	b. sl.	sl. ex.	16-20 s	ph.	dg. sl.	e.	ph.	ph.	21-25 s	ph. r.	dg.	e.	ph.	ph.	26-30 s	ph. dr.	dg.	sl. lo.	ph.	ph. sl.
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EXERCISE

1

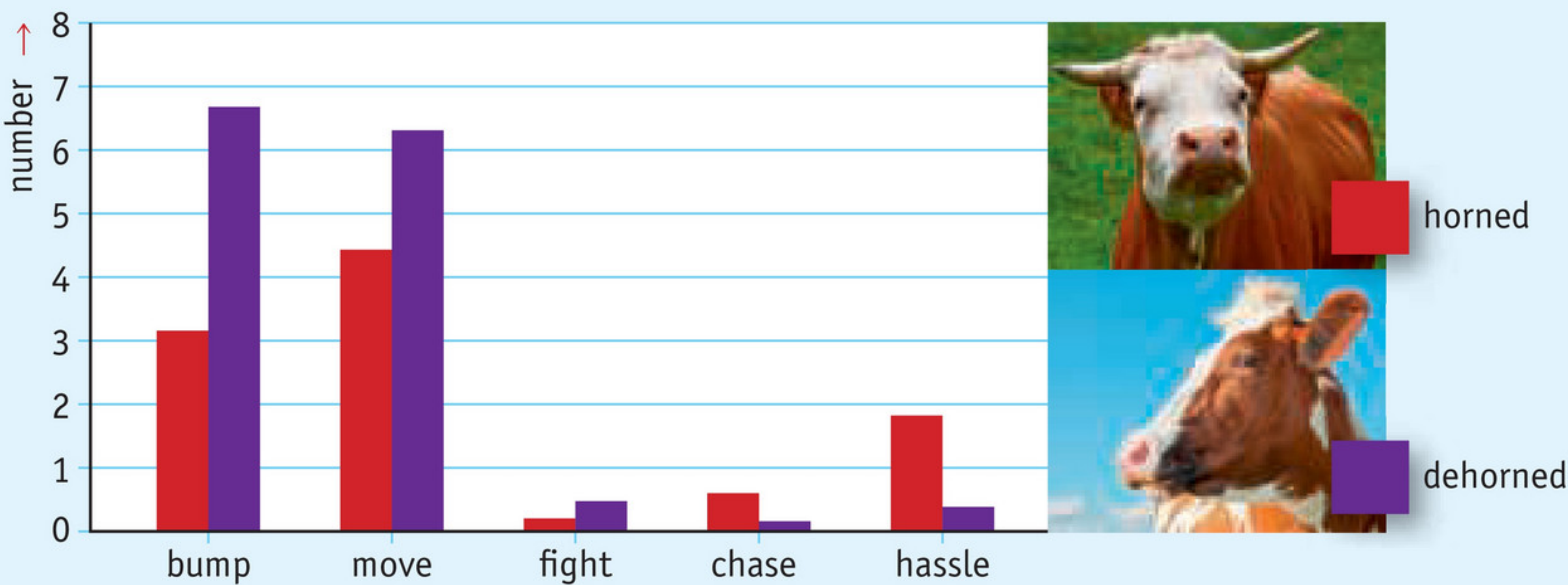
Read the text ‘Behaviour of horned and dehorned cows’ in figure 4. This study was done using an ethogram and fixed action patterns.

- a** Explain why this research is covered by ‘ethology’.
- b** Which actions are in the ethogram for this research?
- c** Which action is noted down most often among cows with horns? Does this number of actions come from the ethogram or the fixed action list?
- d** Two researchers describe the action ‘fight’.
Researcher 1 describes the action as “two cows fight to see who is the boss”. Researcher 2 describes the action as “two cows bump their foreheads or horns against one another”.
Which researcher has given the correct description of the action? Explain your answer.
- e** In the action ‘move’, a lower-ranking cow makes way for a higher-ranking cow. In the action ‘bump’, a cow (usually a lower-ranking one) does not move aside when they get bumped by another cow.
Explain that moving occurs more often than bumping in cows with horns.

fig. 4

Behaviour of horned and dehorned cows

Most farmers dehorn their calves. Some organic farmers don't want to dehorn their cows as they think it is an unnatural practice or not animal-friendly. The researcher Gidi Smolders of Wageningen Livestock Research wanted to know whether the well-being of horned cows is greater than the well-being of dehorned cows. So he investigated whether cows with horns behave differently to dehorned cows. Smolders observed the social behaviour of the cows, especially behaviour related to their ranking in the group. An example of this behaviour is where a higher-ranked cow chases a lower-ranked cow away. Smolders also noted the number of examples of harm or injury to the horned and dehorned cows, such as wounds, scars and bare patches. He discovered that cows with horns had more damage than dehorned cows. Horned cows also behave differently to dehorned ones. That can be seen from the bar chart.



After: G. Smolders, Wageningen Livestock Research, 2011.

Practical activities

1 HEAT RECEPTORS AND COLD RECEPTORS

► Basics 1 | ► Learning objectives 5.1.1, 5.1.2 and 5.0.20 | ► Learning how to do research 1

 15-20 minutes

WHAT ARE YOU GOING TO DO?

Heat receptors respond when something that is warmer than your skin touches it. We say then that the heat receptors are stimulated. Cold receptors are stimulated when something colder than the skin touches it.

You are going to investigate how these senses work in this practical activity.

WORKING METHOD

- Read the research question and the work plan.
- Fill in your hypothesis.
- Carry out the experiment.
- Write down your results.
- Fill in your conclusion.

RESEARCH	HEAT RECEPTORS AND COLD RECEPTORS
Study question	Can the heat and cold receptors in the skin reliably judge the actual temperature?
Hypothesis	
What do you need?	☐ a glass beaker of ice water (approximately 0 °C) ☐ a glass beaker of water at room temperature (approximately 20 °C) ☐ a glass beaker of hot water (approximately 40 °C)
Work plan	Place two fingers of your right hand in a beaker of ice water and two fingers of your left hand in a beaker of hot water (see figure 1). Keep your fingers in the water for two minutes. Then put the fingers of both hands at the same time into a beaker of water at room temperature. fig. 1 
Results	
Conclusion	

2 TOUCH RECEPTORS

► Basics 2 | ► Learning objectives 5.2.3 and 5.0.19 | ► Learning how to do research 1

 25-30 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will be investigating whether the skin has the same number of touch receptors per square centimetre everywhere. You will work in groups of three. One pupil is the test subject. Another pupil carries out the experiment. The third pupil writes down the observations.

WORKING METHOD

- Read the work plan.
- Write down the study question and the research hypothesis.
- Carry out the experiment.
- Write down your results.
- Fill in the conclusion.

RESEARCH	TOUCH RECEPTORS
Study question	
Hypothesis	
What do you need?	☐ a blindfold ☐ measuring compass ☐ a ruler
Work plan	

3 YOUR RECEPTORS FOR SWEET TASTES

► Basics 2 | ► Learning objectives 5.2.5 and 5.0.19 | ► Learning how to do research 1

 15-20 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will be investigating when your taste receptors can sense a sweet taste.

WORKING METHOD

- Read the work plan.
- Think of a research question and fill it in.
- Carry out the experiment.
- Write down your results.
- Fill in the conclusion.

RESEARCH	THRESHOLD VALUE FOR SWEET																													
Study question																														
Hypothesis	–																													
What do you need?	☐ two plastic beakers ☐ sugar solutions of 0%, 0.2%, 0.4%, 0.6%, 0.8%, 1.0%, 1.5% and 2.0%																													
Work plan	Your teacher will give you a little bit of water with or without sugar, eight times. • Before you taste each sugar solution, you should rinse out your mouth with a little bit of water. • Each time, write down in the table whether or not you can taste sugar. • Your teacher will tell you what percentage of sugar each solution contains. Write this down in the table. • Determine the concentration above which you taste sweetness.																													
Results	<table><tr><th>Sugar solution</th><th>Can you taste the sugar?</th><th>Sugar solution concentration</th></tr><tr><td>1</td><td>yes / no</td><td></td></tr><tr><td>2</td><td>yes / no</td><td></td></tr><tr><td>3</td><td>yes / no</td><td></td></tr><tr><td>4</td><td>yes / no</td><td></td></tr><tr><td>5</td><td>yes / no</td><td></td></tr><tr><td>6</td><td>yes / no</td><td></td></tr><tr><td>7</td><td>yes / no</td><td></td></tr><tr><td>8</td><td>yes / no</td><td></td></tr></table>			Sugar solution	Can you taste the sugar?	Sugar solution concentration	1	yes / no		2	yes / no		3	yes / no		4	yes / no		5	yes / no		6	yes / no		7	yes / no		8	yes / no	
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Conclusion																														

EXERCISE

1 Why don't you need to formulate a hypothesis for this experiment?

4 HOW THE TASTE BUDS WORK

► Basics 2 | ► Learning objectives 5.2.5, 5.0.19 and 5.0.20 | ► Learning how to do research 1

 30-40 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will be investigating how your taste buds (taste receptors) work.
You will work in groups of three. One pupil is the test subject. Another pupil carries out the experiment. The third pupil writes down the observations.

WORKING METHOD

- Read the work plan.
- Write down the study question and the research hypothesis.
- Carry out the experiment.
- Make your own table and write down your results in it.
- Fill in the conclusion.

RESEARCH	HOW THE TASTE BUDS WORK
Study question	
Hypothesis	
What do you need?	☐ a blindfold ☐ a knife (or a spatula) ☐ a pot of sugar ☐ a pot of salt ☐ a watch or stopwatch ☐ a glass of water ☐ filter paper or kitchen roll
Work plan	fig. 3  • Blindfold the test subject. In random order, put a pinch of salt and a pinch of sugar three times each on the test subject's tongue using the tip of the knife or spatula (see figure 3). The sugar or salt will dissolve in the saliva on the tongue. • The test subject states what taste they perceive. The third person measures how long the test subject takes to recognise the taste and records the times. Between each observation, the test subject has to rinse their mouth out with water. • Repeat the experiment. This time, the test subject dries their tongue thoroughly with the filter paper or kitchen roll before the taste test. The sugar or salt will now only be able to dissolve once the tongue has slowly become moistened again.
Results	
Conclusion	

5

THE PUPILLARY REFLEX

► Basics 3 | ► Learning objective 5.3.7

 10-15 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will investigate your own pupillary reflex.

WHAT DO YOU NEED?

- ☐ the tube of a toilet roll
- ☐ a mirror

WORKING METHOD

- Shut one eye.
- Hold the toilet roll tube between the other eye and the mirror (see figure 4.1). Make sure there is just enough light to be able to see your pupil. Note the size of your pupil.
- Move your head back a little bit (see figure 4.2). More light can then reach your eye. Note how the size of the pupil changes.

fig. 4



1



2

EXERCISE

1

You started with your eye close to the cardboard tube.

- a Was the pupil large or small then? What about the iris?
The pupil was *large / small* and the iris was *large / small*.
- b Was the light reaching your eye bright or dim then? *bright / dim*
- c Then you moved your head back a bit.
Did the pupil become larger or smaller then? What about the iris?
The pupil became *larger / smaller* and the iris became *larger / smaller*.
- d Did the light reaching your eye become brighter or dimmer then? *brighter / dimmer*
- e What is the function of the pupillary reflex?

6

THE PATELLAR REFLEX

► Basics 4 | ► Learning objective 5.4.10

 10-15 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will investigate your patellar reflex.
Do this practical activity together with a classmate.

WHAT DO YOU NEED?

☐ a reflex hammer or a ruler

WORKING METHOD

- Cross your right leg over your left knee. Make sure that your right foot is not touching the ground and that your lower leg is hanging loose and relaxed.
- Get your classmate to give you a tap on the patellar tendon, just below the kneecap (see figure 5).

fig. 5

**EXERCISE**

1

- a** How did your lower leg respond to the tap?
b Did you try to make this movement voluntarily? *yes / no*

7

AN ANIMAL'S BEHAVIOUR

► Basics 5 | ► Learning objective 5.0.21 | ► Learning how to do research 2

 **Lesson 1: preparation, 20-30 minutes; lesson 2: carrying out the activity, 70-80 minutes; lesson 3: analysis, 25-35 minutes**

WHAT ARE YOU GOING TO DO?

In this practical activity, you will be investigating the behaviour of an animal. You can investigate the behaviour of a live animal or you can use a video clip.
Choose which animal (or human) you are going to investigate and where you are going to make observations, after discussion with your teacher.
Do this practical activity together with a classmate.

WORKING METHOD

Carry out the exercises in the research table and complete the rest of the table.

RESEARCH	BEHAVIOUR IN AN ANIMAL
Study question	
Hypothesis	<i>You won't always need to formulate a hypothesis for this study. Discuss with your teacher whether it is needed.</i>
What do you need?	
Work plan	• Study some animals of the species that you want to investigate and make an ethogram of the actions you observe. Choose just the actions that you want to use to answer the study question. • Make a list of fixed actions for the behaviour you observe. It usually helps to observe the behaviour of just one animal. Work together as follows: – One pupil says each time when the time is up (for example, 5 seconds or 30 seconds). – One pupil writes down the abbreviations for the actions.
Results	Show both the ethogram and the protocol. Make a bar chart of your results too.
Conclusion	

Summary

BASICS 1

OBSERVING YOUR SURROUNDINGS

1 You can describe how the senses work.

- Sense: an organ that reacts to certain stimuli.
 - stimulus: an influence from the surroundings on an organism
- When sensory cells receive stimuli, they generate impulses.
 - Impulses are electrical signals that are transmitted from the senses to the brain via nerves.
 - The brain processes the impulses that come from the senses.
- Pain receptors (the ends of certain nerves): perceive pain. Pain receptors are everywhere in the body.

2 You can name the senses along with their locations and their stimuli.

Sensory organ	Location	Stimulus
Sight	in the eyes	light
Sense of hearing	in the ears	sound
Sense of balance	in the ears	gravity
Sense of smell	in the nose	odour
Sense of taste	in the tongue	taste
Heat receptor	in the skin	heat
Cold receptor	in the skin	cold
Pressure receptor	in the skin	pressure
Sense of touch	in the skin	gentle contact

BASICS 2

TOUCH, SMELL, TASTE

3 You can describe the structure and functions of the skin.

- Epidermis: corneal layer and basal layer.
 - Corneal layer (dead, cornified cell residues): protects against damage, dehydration and pathogens (bacteria).
 - Basal layer (living cells): the bottom layer of cells divides continuously. This adds new layers to the continuously corneal layer as it continually wears away.
- Dermis with sensory receptors, nerves, pain receptors, hair muscles, blood vessels and sweat glands.
 - Hair with follicle (protrusion of the basal layer) and sebaceous glands.
 - Sebum keeps the hair and the corneal layer flexible.
 - Senses: heat, cold, pressure and touch receptors.
 - Touch receptors are found just below the epidermis. The pressure receptors are found deeper in the skin.
 - Sweat glands: produce sweat. Evaporation of sweat cools the body down.
- Subcutaneous connective tissue.
 - stores fat. The fat is used as reserve food and has an insulating effect.
- A burn is damage to your skin caused by heat, a chemical substance or electricity.

4 You can say how you smell different scents.

- Olfactory system: sensory cells are located in the nasal lining in the roof of the nasal cavity.
 - Different types of olfactory cells are sensitive to different scents.
 - The brain translates the pattern of impulses into a smell.

5 You can say how you taste different flavours.

- The sides of the grooves in the tongue have taste buds.
 - The taste buds contain the sensory cells for taste.
 - There are separate taste buds for the flavours sweet, sour, salty, bitter and umami.
 - Tasting all other flavours is a result of the sense of smell registering smells.

BASICS 3

HEARING AND SEEING**6 You can list the parts of the ear and their functions.**

- Outer ear (auricle): collects sounds.
 - Sounds are vibrations in the air.
- Auditory canal: conducts sounds to the eardrum.
 - Earwax glands: produce earwax, which keeps the eardrum flexible.
- Eardrum: made to vibrate by sounds.
- Tympanic cavity: space behind the eardrum filled with air.
 - Ossicles (hammer, anvil, stirrup): transmit the vibrations of the eardrum to a membrane (the oval window) in the cochlea.
- Cochlea: contains a fluid and sensory cells.
 - The vibrations in the fluid make the sensory cells give off impulses.
- Auditory nerve: passes impulses to the brain.
- Eustachian tube: connects the tympanic cavity to the pharynx.
 - The Eustachian tube opens when you swallow or yawn. This makes the air pressure on both sides of the eardrum the same again.

7 You can describe the structure and functioning of the eye.

- Organs around an eye:
 - Eyebrows: make sure that sweat (liquid) runs past the eyes and not into them.
 - Eyelashes: protect the eyes against dirt and bright light.
 - Tear glands: produce tears. Tears protect the eyes against dehydration and clean them.
 - The tears drain to the nasal cavity.
- Parts of the eye:
 - Eye muscles: turn the eye in the desired direction.
 - Sclera (white): tough, provides protection.
 - Cornea (transparent): at the front of the eye, the sclera gives way to the cornea.
 - Choroid: contains a lot of blood vessels; the choroid takes nutrients to most of the eye.
 - Iris (coloured): at the front of the eye, the choroid becomes the iris.
 - Pupil: opening in the iris.
 - Lens: behind the iris and the pupil. The lens makes sure that you can see sharply.
 - Retina: contains sensory cells. Light creates impulses in the sensory cells.
 - Fovea: place in the middle of the retina. The sensory cells in the fovea let you see most sharply.
 - Optic nerve: transmits impulses to the brain.
 - Blind spot: the point on the retina where the optic nerve leaves the eye. The blind spot does not contain sensory cells.
 - Vitreous body (jelly-like): keeps the retina in place.
- Function of the pupillary reflex: regulates the amount of light reaching the retina.
 - The sensory cells in the retina are protected against light that is too bright by the pupillary reflex.

- Short-sighted:
 - can only see nearby things sharply
 - the eye lens is too round or the eyeball is too long (too deep)
 - image ends up in front of the retina
 - glasses or contact lenses with concave lenses
- Long-sighted:
 - can only see distant things sharply
 - the eye lens is too flat or the eyeball too short
 - image ends up behind the retina
 - glasses or contact lenses with convex lenses

BASICS 4

THE NERVOUS SYSTEM

8 You can describe the structure and functions of the nervous system.

- Parts of the nervous system:
 - the central nervous system: brain and spinal cord
 - nerves
- Nerves connect all parts of the body to the central nervous system.
 - Parts of the head and neck are connected by nerves directly to the brain.
 - The torso and limbs are connected by nerves to the spinal cord.
- Functions of the nervous system:
 - processing impulses from the senses
 - controlling the functions of the muscles and glands
- A gland is an organ that produces certain substances.

9 You can describe the structure of nerve cells and nerves.

- Structure of a nerve cell:
 - cell body with nucleus
 - axons that pass impulses to the cell body
 - axons that transmit impulses from the cell body
- Nerve: a bundle of nerve cell axons surrounded by a tough, protective layer.
 - Each axon in a nerve is surrounded by a thin insulating layer.

10 You can describe a reflex arc.

- In a voluntary reaction, the impulses go via the brain.
- Reflex: a fixed, fast and unconscious reaction to a certain stimulus.
 - The speed is often needed to protect the body against injuries.
 - Examples: withdrawal reflex, patellar (knee-jerk) reflex, eyelid reflex, pupillary reflex.
- There are interneurons in the spinal cord and brain: these are nerve cells that conduct impulses within the central nervous system (from one nerve to another).
- Reflex arc: the path the paths taken by the nerve impulses in a reflex.
 - Stimuli lead to impulses in the nerve cells.
 - The impulses are passed to interneurons in the spinal cord via nerve cells.
 - Interneurons immediately pass the impulses to nerve cells that are connected to the muscles.
 - These nerve cells pass the impulses to muscle cells, making muscles contract.
 - Interneurons also send impulses to the brain, which makes you aware of the stimulus.

BASICS 5

BEHAVIOUR

11 You can explain what behaviour is.

- Behaviour: everything that humans or animals do.
 - Behaviour consists of interrelated actions.
 - Together, these actions have a purpose.
 - Chain of behaviour: actions that have a fixed sequence, with the effect of one action leading to the next.
- Behaviour is triggered by stimuli.
 - response: a reaction to a stimulus
 - internal stimulus: a stimulus that arises inside the body (e.g. hunger)
 - external stimulus: a stimulus that comes from outside the body
 - motivation: the willingness to react to stimuli

12 You can explain what determines behaviour.

- Behaviour is partly determined by hereditary factors and partly learned.
- Social behaviour: behaviour of members of the same species towards each other.
- Signal: an action in social behaviour that acts as a stimulus for another action by a member of the same species, e.g. putting a hand up as a greeting.
 - Signals allow communication between members of the same species.
- People judge their own and others' behaviour using norms and values.
 - values: the things that people find important in life
 - norms: rules of behaviour based on values

13 You can explain the difference between observation and interpretation of behaviour.

- Observation of behaviour: what you actually see.
- Interpretation of behaviour: what you think it means.

BASICS 6

REGULATION

14 You can say what feedback is and give examples of it.

- The endocrine system consists of a number of endocrine glands that produce hormones.
 - Endocrine glands secrete their hormones into the bloodstream.
 - Hormones are substances that control the functioning of organs.
- Islets of Langerhans: in the pancreas.
- Adrenal glands: like caps on top of the kidneys.
- Feedback: the result of a process triggers an adjustment to the process.

15 You can describe how adrenaline, glucagon and insulin work.

- The islets of Langerhans produce insulin and glucagon.
 - Insulin and glucagon control the blood glucose level (the blood sugar level). The glucose level is kept more or less constant.
 - When the blood glucose level is high, the islets of Langerhans produce a lot of insulin. Insulin makes the liver and muscles convert glucose into glycogen. Glycogen is stored.
 - When the blood glucose level is low, the islets of Langerhans produce a lot of glucagon. Glucagon makes the liver and muscles convert glycogen into glucose. The glucose is taken up in the blood.
- The adrenal glands release the hormone adrenaline if you are angry or scared or get a shock.
 - Adrenaline makes the liver convert glycogen into glucose.
 - Your heart beats faster and you breathe faster.
 - Adrenaline prepares the body for a quick reaction.
 - Adrenaline is the only hormone with a fast, short-term effect.

EXTRA 7

SENSES AND IMPULSES (IN DEPTH)**16 You can explain when senses convert stimuli into nerve impulses.**

- Threshold value: the smallest stimulus that triggers an impulse.
 - Impulse frequency: the number of impulses per second. The impulse strength is always the same.
- Adequate stimulus: the type of stimulus that a sensory cell is particularly sensitive to.
 - The sensory cell has a low threshold value for this stimulus.
- The threshold value is not always the same.
 - Habituation: if a stimulus persists for some time, the sensory cells will start producing fewer impulses.

17 You can state the structures and functions of three types of nerve cells.

- Sensory neurons:
 - Function: to pass the impulses from the sensory organs to the central nervous system.
 - Their cell bodies are near the central nervous system.
 - They have one long axon, which passes impulses to the cell body.
- Motor neurons:
 - Function: to pass impulses from the central nervous system to muscles or glands.
 - Their cell bodies are in the central nervous system.
 - They have one long axon, which passes impulses away from the cell body.
- Interneurons:
 - Function: to conduct the impulses within the central nervous system.
 - Interneurons are entirely within the central nervous system.
 - They connect the axons of sensory neurons to the axons of motor neurons.

EXTRA 8

HEARING DAMAGE (EXTENSION)**18 You can explain how loud noise can lead to hearing damage.**

- Sounds are vibrations in the air.
- Sound frequency: speed with which sound vibrations follow one another.
 - The sound frequency (pitch) is expressed in hertz (Hz).
 - High sound frequency: fast vibrations, high pitch.
 - Low sound frequency: slow vibrations, low pitch.
 - Older people become increasingly less able to hear high-pitched tones.
- Volume (sound level) is expressed in decibels (dB).
 - large amplitude: loud sound
 - small amplitude: quiet sound
- Loud noise for too long causes hearing damage.
 - The cilia in the sensory cells are damaged.
 - The sense of hearing no longer works well; you often get a constant ringing in the ears (tinnitus).
- You should take precautions to prevent hearing damage.
 - not too loud, not for too long and use hearing protection if necessary
- Cochlea: contains a fluid, the basilar membrane and sensory cells.
 - Vibrations in the fluid are transmitted to the basilar membrane, which then stimulates the sensory cells, which emit impulses.
 - A specific part of the basilar membrane starts vibrating for each sound frequency: from high frequencies at the front of the cochlea to low frequencies in the back of the cochlea.

RESEARCH

LEARNING HOW TO DO RESEARCH & PRACTICAL ACTIVITIES**19 You can formulate a research question (with help).****20 You can formulate a hypothesis.****21 You can make an ethogram and fixed action list (with help).**

 Go to the *Flash cards* and the *Diagnostic test*.

6

Reproduction in plants and animals

Seed plants have flowers from which fruits with seeds can grow. During fertilization, a male sex cell and a female sex cell (the gametes) fuse. Some seed plants can reproduce without fertilization.

BASICS

1	Flowers	166
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	<i>Of flowers and schrimps</i>	

EXTRA

7	Dispersal of seeds	212
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RESEARCH

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TO FINISH

	Summary	233
	Diagnostic test	





1 Flowers

LEARNING OBJECTIVE

6.1.1 You can name the parts of a flower with their features and functions.

► Practical activities 1, 2 and 3

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES	
	6.1.1	5.1.2**
Remembering	1, 3	
Understanding	2, 4	
Using	5ac	8b
Analysing	5b, 6, 7, 8ac	

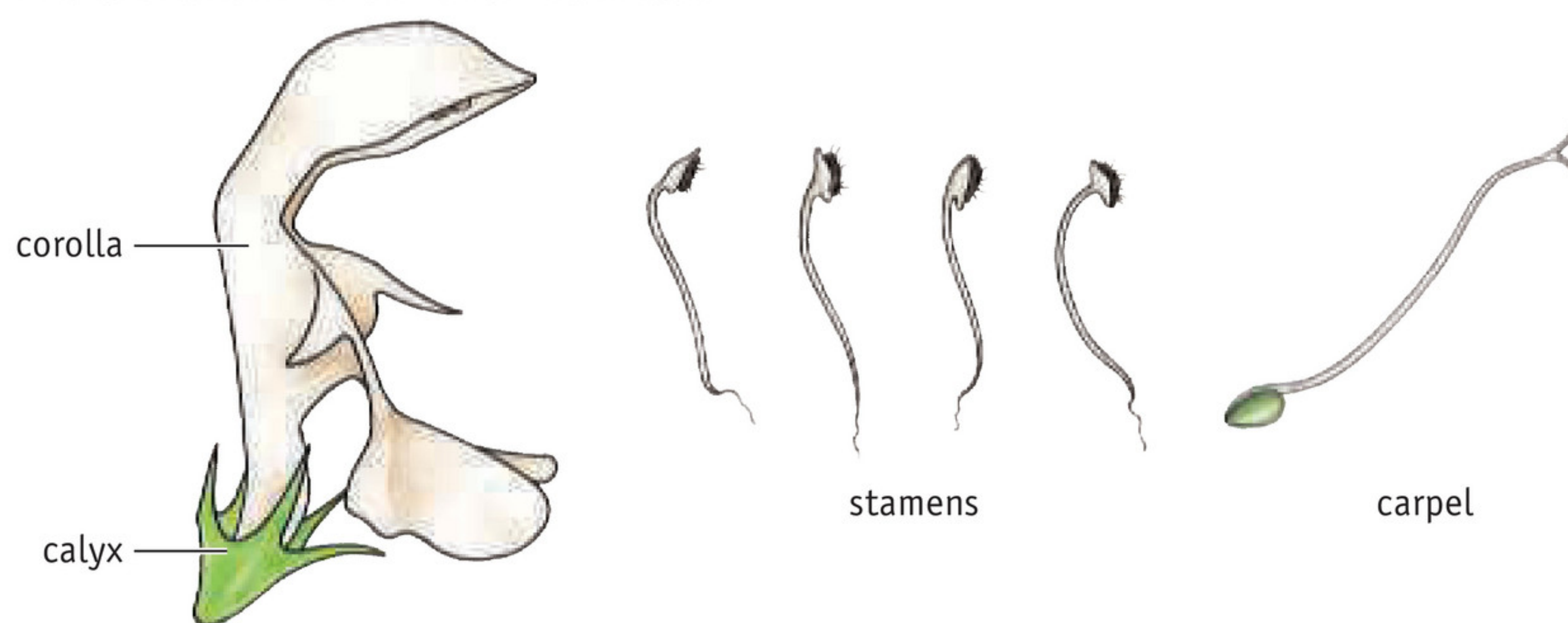
**You can find this learning objective in another unit.

Huge numbers of flowers are grown and sold in the Netherlands. You may come across them anywhere in the world. The world's largest flower auction is in the Netherlands.

A FLOWER

Flowers are plant organs. Their function is reproduction. The flower of a white deadnettle consists of a green part and a white part (see figure 1). The green part is called the **calyx** and the white part is the **corolla**. The flower contains the reproductive organs: the stamens and the carpel (or pistil).

fig. 1 Parts of a flower of the white deadnettle.



The calyx consists of **sepals**. These are generally green. In some plants, the sepals have grown together. They are then said to be fused. While the flower is still a bud, the calyx protects the rest of the flower against dehydration and cold. The corolla is made up of **petals**. In many plants, the petals are large and strikingly coloured (see figure 2.1). Their function is to attract insects that pollinate the plant. In other plants such as grasses, the petals are small and green (see figure 2.2). Just like the sepals, the petals may also be fused or separate.

fig. 2



1 poppies

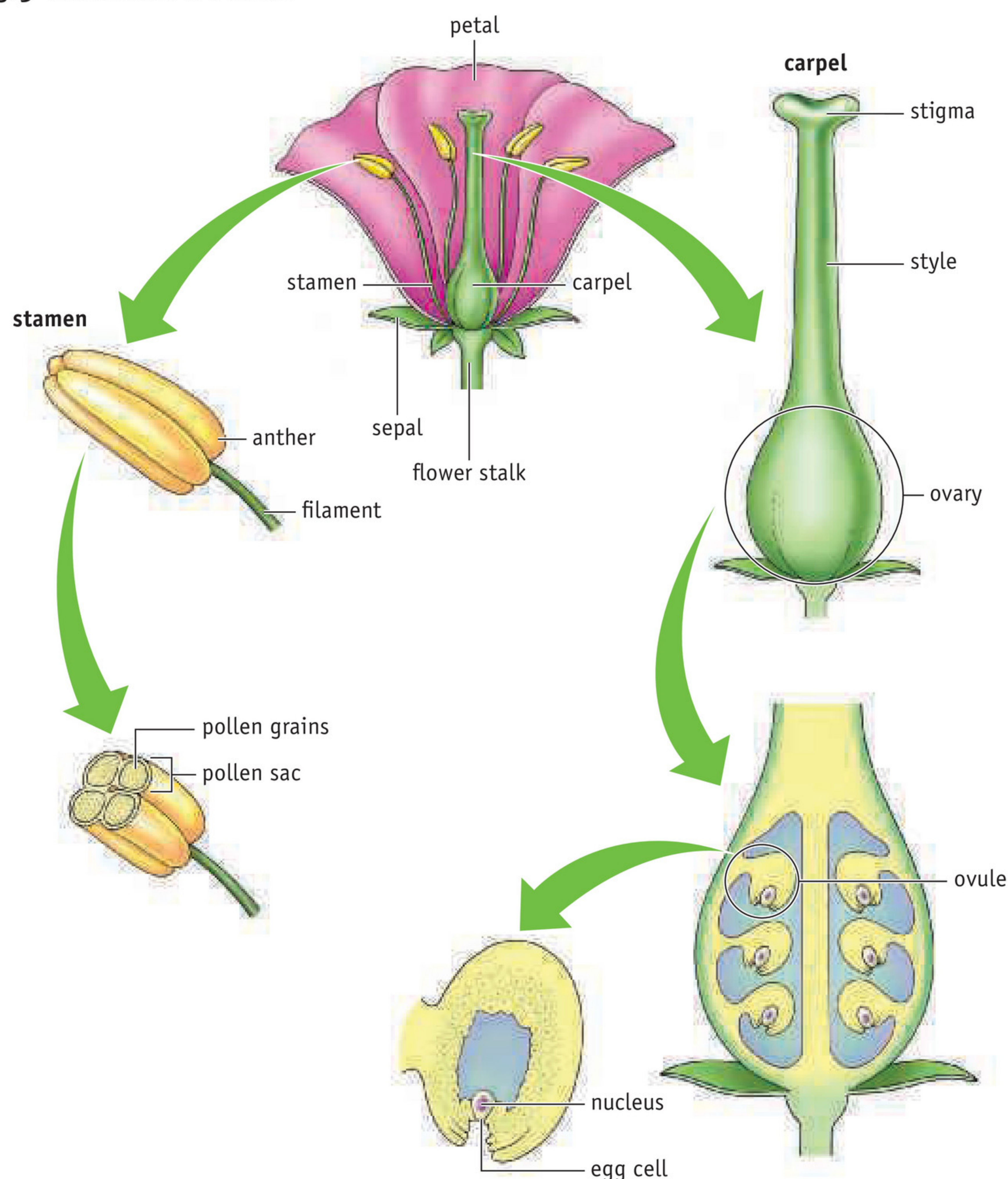


2 grass flowers

THE STRUCTURE AND FUNCTION OF FLOWERS

Flowers can look very different but most of them have roughly the same structure. Figure 3 is a schematic drawing of a flower.

fig. 3 The structure of a flower.



The **stamens** are the male reproductive organs of a plant. A stamen is made up of a **filament** and an **anther**. The anther consists of **pollen sacs** in which pollen is produced. Pollen is a powder that is made up of very small particles called pollen grains. **Pollen grains** are the male sex cells of a plant. When the pollen sacs open, pollen grains are released.

The **carpel** (pistil) is the female reproductive organ of a plant. In many plant species, the flowers have just a single carpel, but there are also plant species with multiple carpels (a compound pistil) in the flowers.

A carpel usually consists of a **stigma**, a **style** and an **ovary**. The ovary contains one or more **ovules**. Each ovule produces a single egg cell. An **egg cell** is a female sex cell. There is a nucleus in each egg cell. Pollen grains have nuclei too.

KNOWLEDGE

1

Many flowers have a green part and a coloured part.

a What is the function of flowers?

.....

b The calyx is usually *coloured* / *green* and the corolla is usually *coloured* / *green*.

c The leaves of the calyx are called and the leaves of the corolla are called

d What is the function of the calyx?

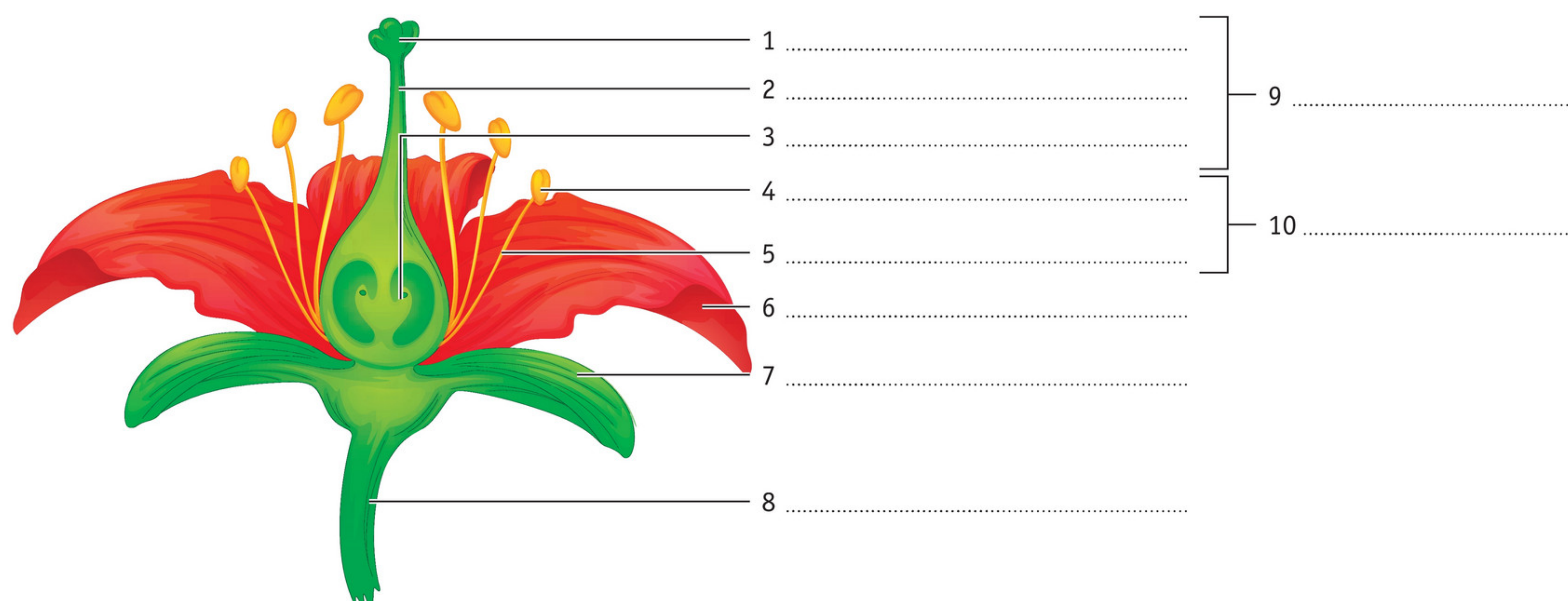
e What is the reason for having a large, striking corolla?

2

Figure 4 shows a schematic drawing of a flower.

Write down the names next to the numbered parts.

fig. 4



3

a The stamens are the *male* / *female* reproductive organs of a plant and the carpels are its *male* / *female* reproductive organs.

b The male sex cells of a plant are called

They are formed in, which are located in the

c A female sex cell is called an (or ovum, plural 'ova'). It is formed in a in the

d Does an egg cell have a nucleus? *yes / no*
 Does a pollen grain have a nucleus? *yes / no*

4

**Summary**

Make a summary of the Basics section using figure 5. Remember to include the functions of the various parts.

fig. 5

**INSIGHT**

5



Figure 6 shows you a photo of a courgette plant with two flowers.

- a** Label the sepals in the figure.
- b** The flowers of a courgette plant can be either male or female. The male flowers only have stamens and the female flowers only have a carpel. The ovary is part of the carpel.
Which is the female flower: the flower on the left or the flower on the right? Explain your answer.
- c** Do both flowers produce pollen? Explain your answer.

6

The calyx is often green.
What advantage does this have for the plant?

fig. 6 Courgette plant with two flowers.

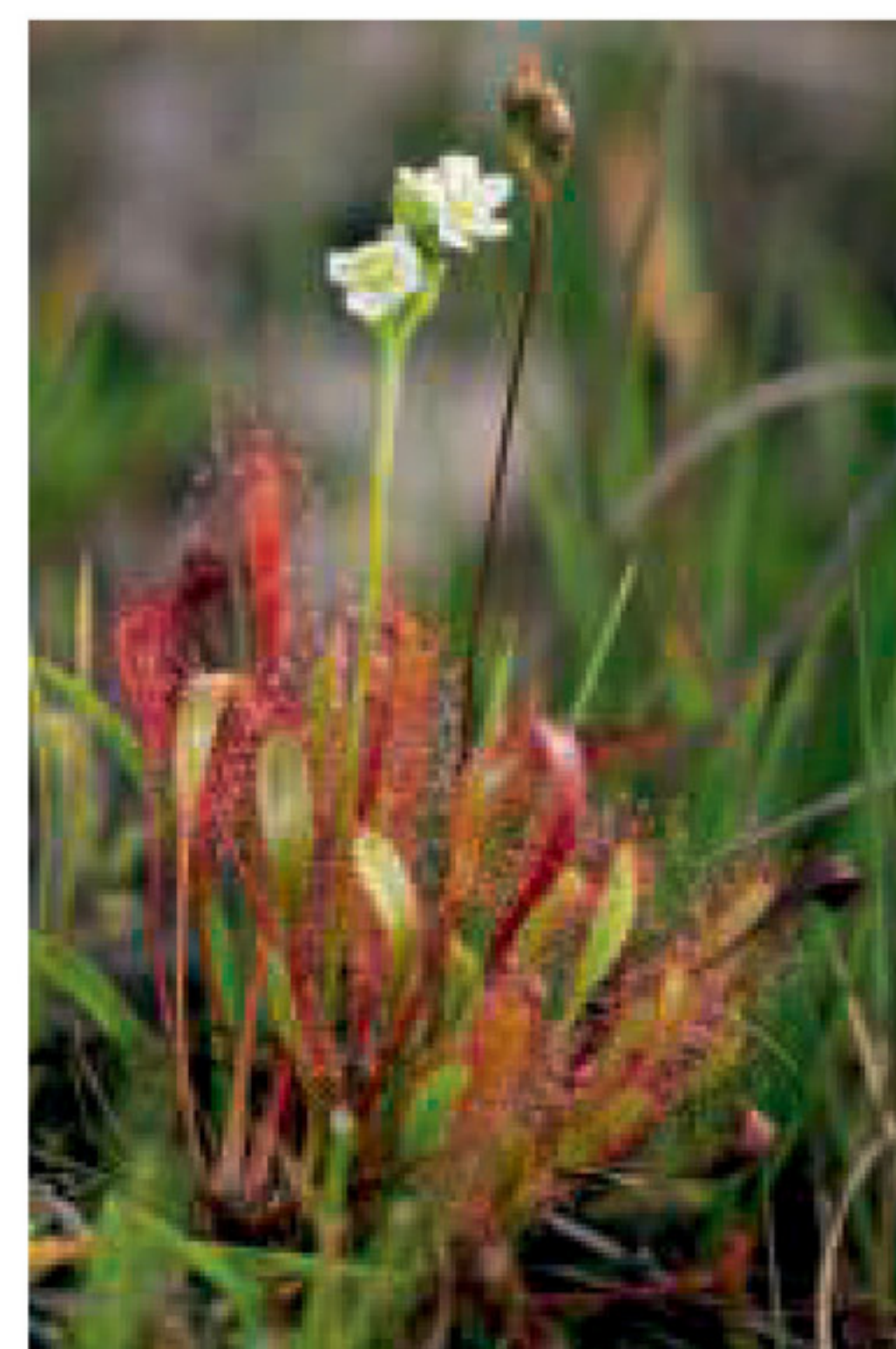
+ 7

The sundew (see figure 7) is a carnivorous plant that can be found in the Netherlands and it gets nutrients from insects. The plant catches them using red leaves that have hairs with sticky droplets of fluid. These red leaves are called traps. Sundews have white flowers that only open on a single day each year.

Biologists have shown that insects are most attracted to white leaves and least attracted by red leaves.

- a Explain why the petals of the sundew are white.
- b The flowers of the sundew only open for one day a year.
What would be the disadvantage for the plant if the flowers were open for longer?
- c The flowers rise up high above the dangerous leaves.
Give an explanation for this.

fig. 7 The sundew.



HOW IT FITS TOGETHER the living world

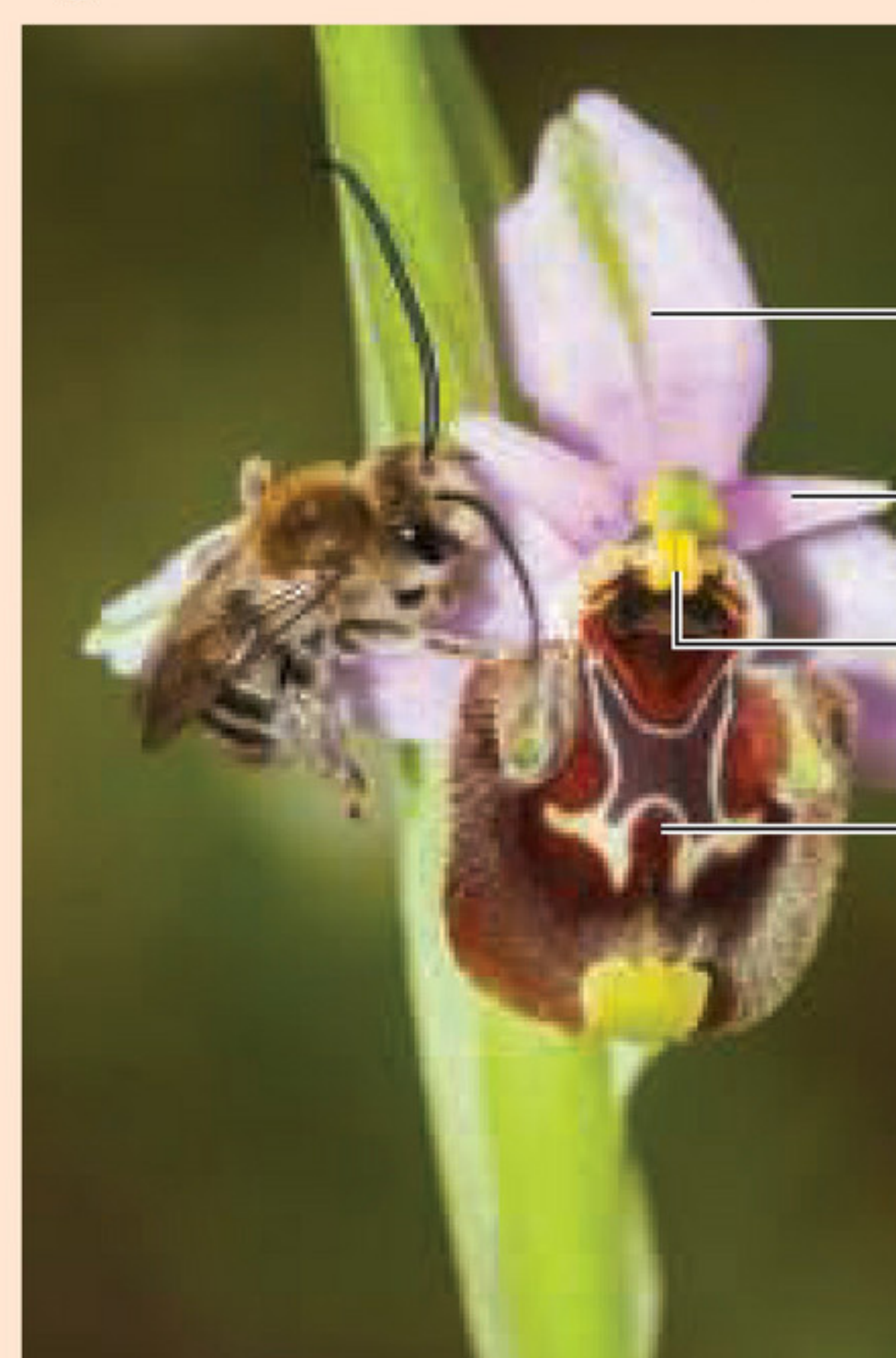
MIRROR ORCHIDS

Mirror orchids try very hard to attract insects. Their shape and colour make them look exactly like their visitors (see figure 8). To attract insects, they use not only coloured sepals and petals but also a special “lip” that resembles a bee. But it does not end there: they release odours that resemble the pheromones of female insects. There are many different kinds of mirror orchids, all with flowers in the shape of an insect species. These can be wasps, bees, bumblebees and even beetles or other insects.

Inexperienced young male insects in particular mistake the flowers for a female.

They try to mate with the flower, so they touch the anther and get pollen stuck on their heads and abdomens. They then fly to the next flower, where the ‘mating ritual’ starts again.

fig. 8 A mirror orchid that looks like a bee.



- 1
- 2
- 3
- 4

8

Read the text about “Mirror orchids” and have a look at the mirror orchid in figure 8.

- a Write down the names of the numbered flower parts.
- b What senses do insects use to find flowers?
- c In insects, males generally start flying earlier than females. The mirror orchids are therefore in full bloom at just the right moment: before the females start flying.
Explain why that is the right moment for the mirror orchids.

 Go to the *Flash cards* and the *Test yourself* section.

2 Pollination

LEARNING OBJECTIVES

- 6.2.2 You can describe what pollination is.

6.2.3 You can explain the difference between cross-pollination and self-pollination.

6.2.4 You can list the features of insect-pollinated flowers and wind-pollinated flowers.
- Learning how to do research 1

► Practical activities 4 and 5

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	6.2.2	6.2.3	6.2.4
Remembering	1ab	2	3abcd
Understanding	1cd, 4	4	4
Using	5, 6a	6a	3e, 6bc, 10abc
Analysing		9	7, 8, 10d

Many flowers have large and strikingly coloured petals. These are used for attracting insects. Insects also respond to the scent and the nectar.

NECTAR AND POLLEN

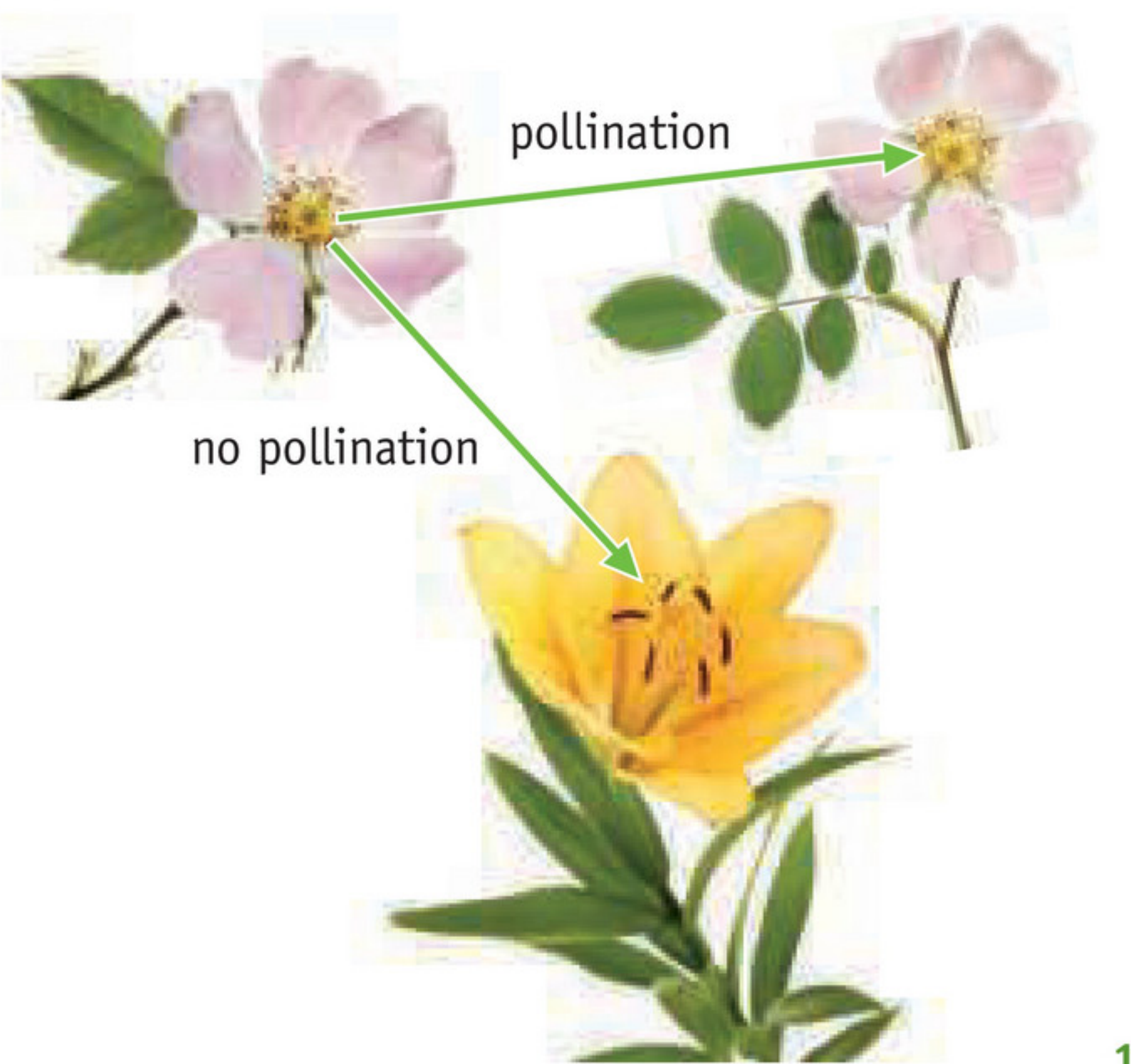
Like many other flowers, the white deadnettle produces **nectar**. Nectar is a sweet juice that attracts insects. The bees collect nectar and use it to make honey for their offspring (the larvae). While it is collecting nectar, a bee often gets covered in pollen (see figure 1). When the bee then flies to another flower, it takes the pollen with it. This is how the pollen ends up on the other flower. Hummingbirds and some bats also disperse pollen.

fig. 1 Pollinators.



Transferring pollen from a stamen to the stigma is called **pollination**. Pollen grains do then have to get onto the stigma of the flower of the same plant species. If pollen ends up on the stigma of a flower of a different plant species, this is *not* pollination (see figure 2).

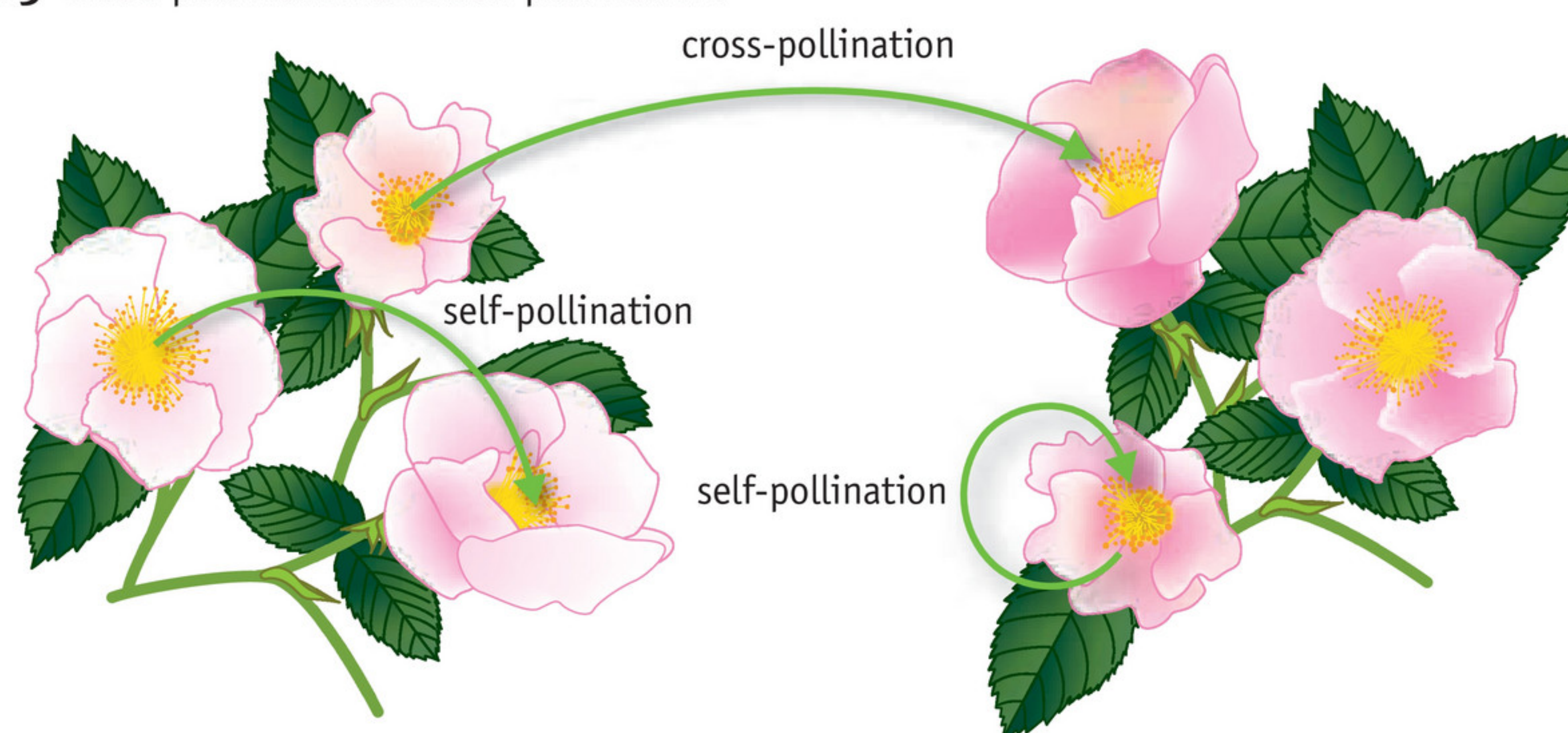
fig. 2 Pollination or not?



CROSS-POLLINATION AND SELF-POLLINATION

Many flowers have both stamens and carpels. Pollen from the stamens can get onto the stigma of the carpel of the same flower. This is called **self-pollination**. Some plants have more than one flower. Pollen from one flower can then get onto the stigma of another flower on the same plant. This is also self-pollination. Pollen can also get onto the stigmas of flowers of a different plant (of the same species). This is then called **cross-pollination** (see figure 3).

fig. 3 Cross-pollination and self-pollination.

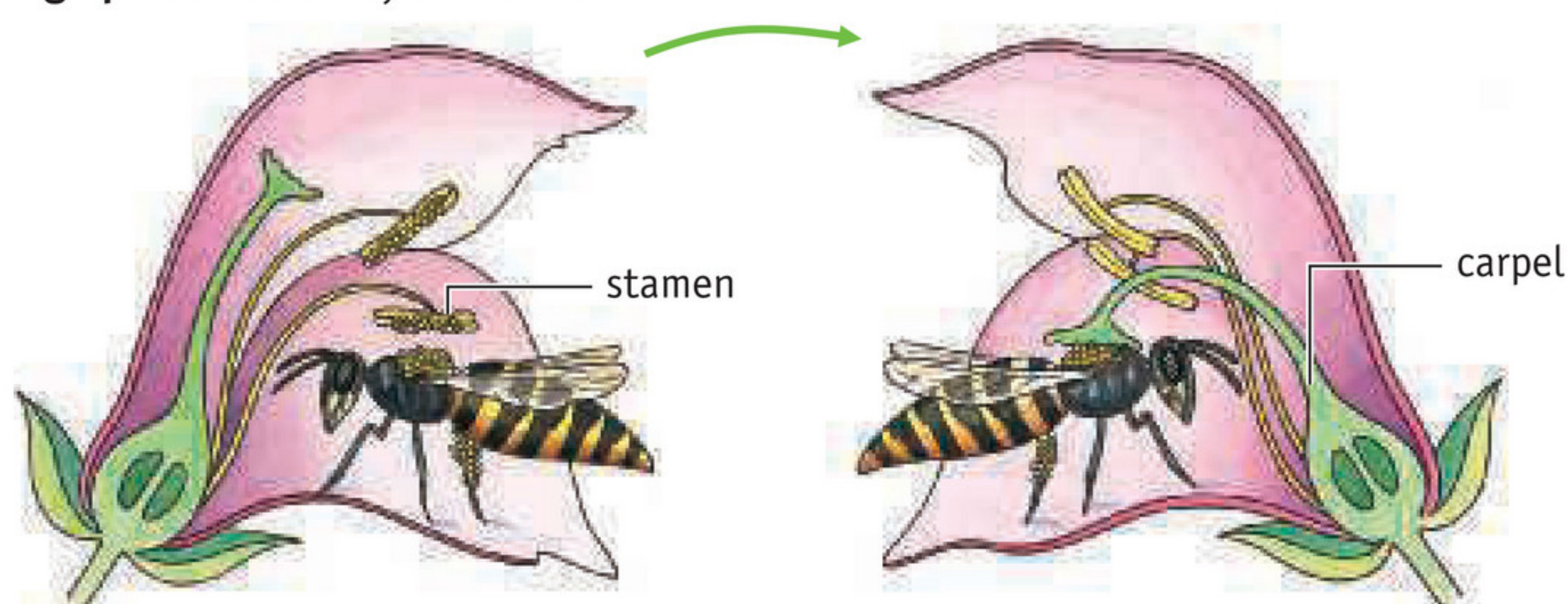


INSECT-POLLINATED FLOWERS AND WIND-POLLINATED FLOWERS

Flowers that are pollinated by insects are called **insect-pollinated flowers**.

Insect-pollinated flowers generally have large and strikingly coloured petals to attract insects. Insects also respond to the scent and the nectar. The pollen sticks to their bodies. Their bodies touch the stigma of the next flower (see figure 4). Pollen grains will then get stuck to the stigmas. A single insect can pollinate dozens of flowers this way.

fig. 4 Pollination by an insect.

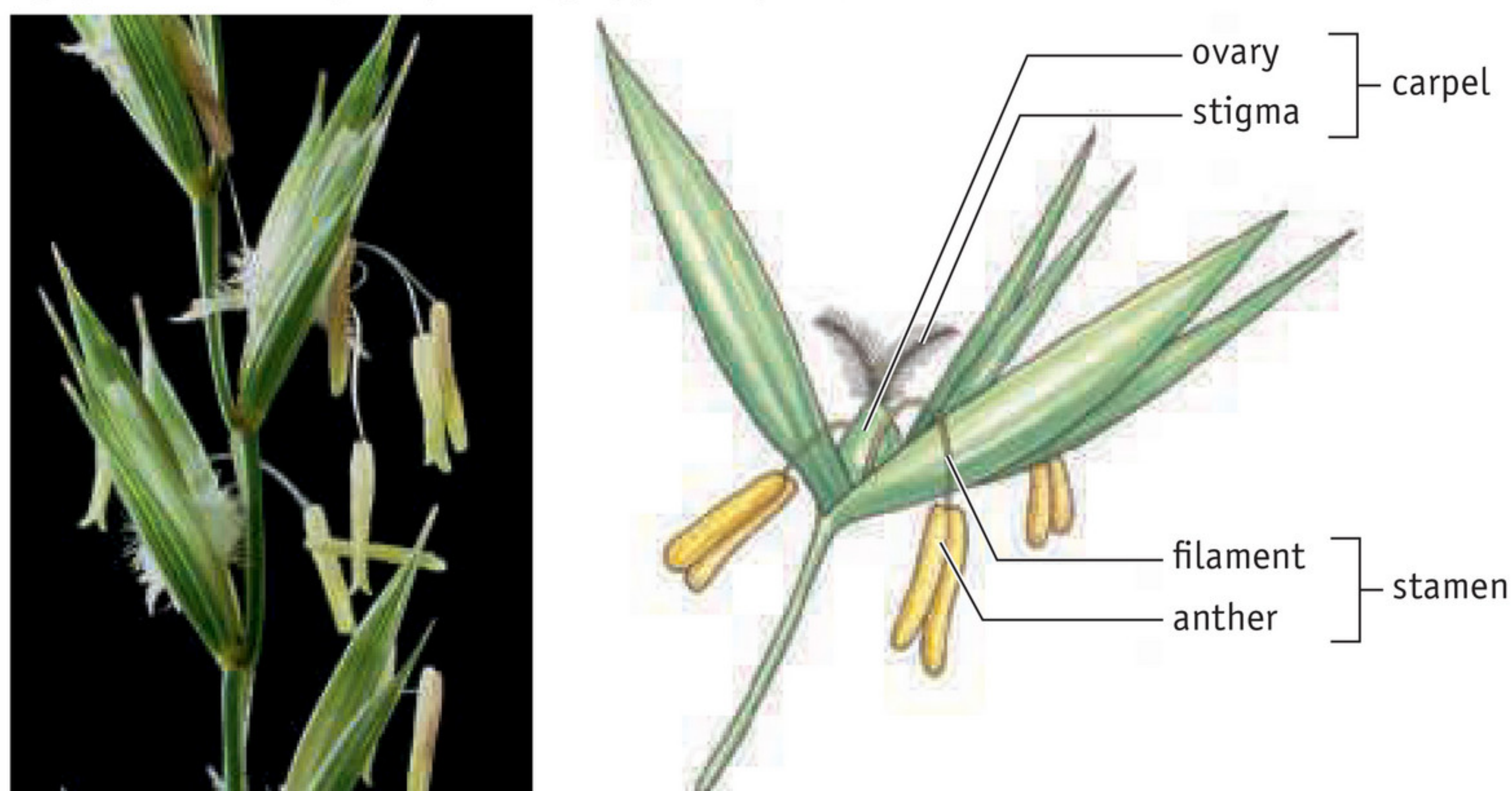


Other flowers are pollinated by the wind. These are **wind-pollinated flowers**.

Wind-pollinated flowers are often small and inconspicuously coloured. The petals are generally green. In wind-pollinated flowers, the wind blows the pollen away from the stamens. The pollen may then end up on the stigma of a flower of the same plant species simply by chance. This is not very likely. Wind-pollinated flowers therefore produce large amounts of pollen compared to insect-pollinated flowers.

The anthers of wind-pollinated flowers often hang outside the flower to make it easy for the pollen to be blown away (see figure 5). The stigmas are large and feathery, and generally protrude outside the flower. This increases the chance of pollination.

fig. 5 Flowers of a grass plant (*Agropyron repens*).

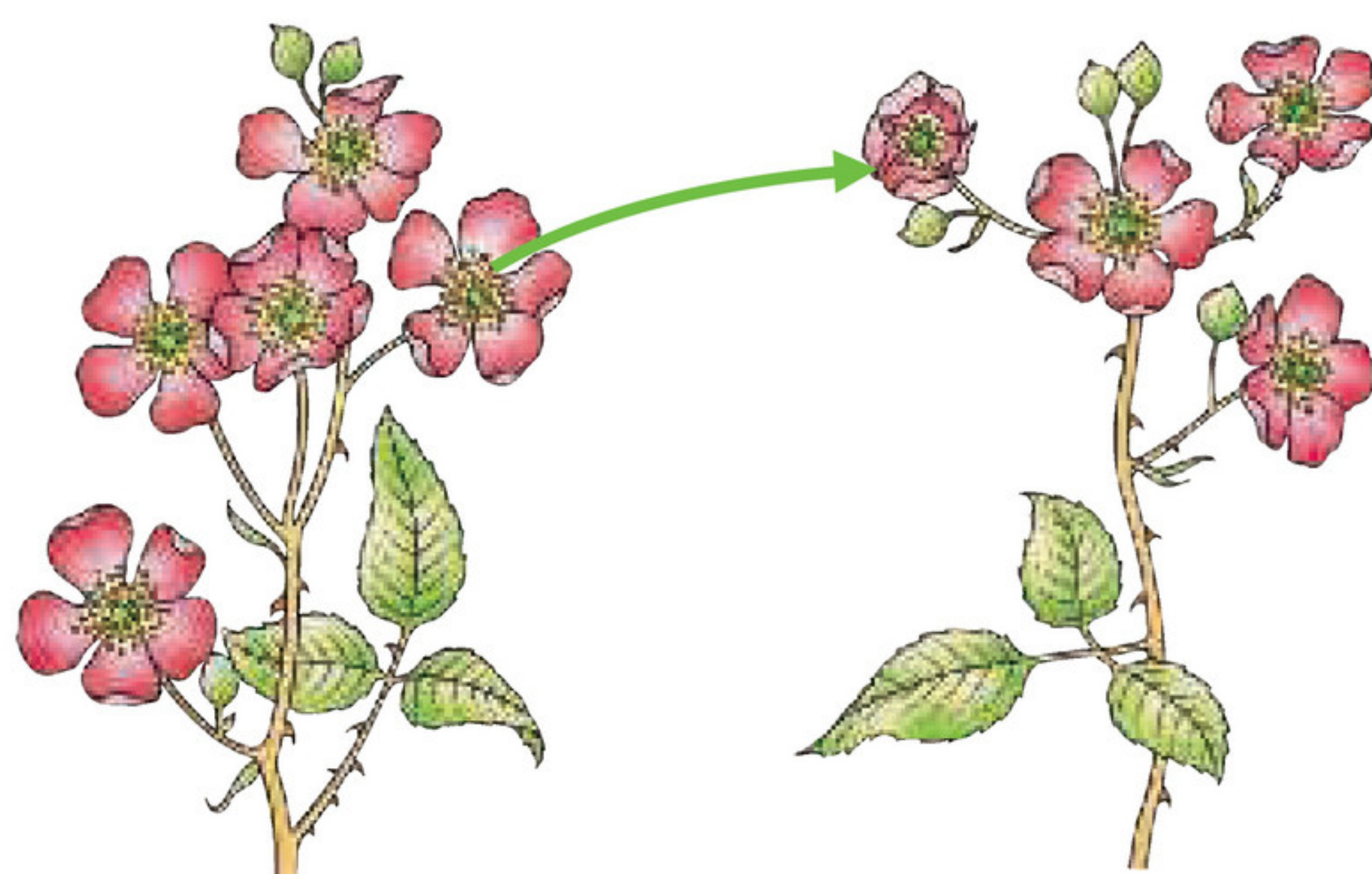


KNOWLEDGE

1

- a Bees visit flowers to get to make honey for their young. A bee collecting nectar often gets covered in
- b What is pollination?
- c Explain why one insect can pollinate dozens of flowers.
- d Figure 6 shows two rosebushes. The arrow shows pollen getting onto a stigma. Explain that pollination is taking place here. Write down two things that had to happen.

fig. 6



2

- a If pollen from the stamens gets onto the stigma of the same flower, it is
- b If pollen gets onto the stigma of a flower of a different plant (of the same species, it is

3

- a The petals of insect-pollinated flowers are generally *large / small* and *inconspicuous / conspicuous*.
- b The petals of wind-pollinated flower are generally *large / small* and *inconspicuous / conspicuous*.
- c Insect-pollinated flowers make *more / less* pollen than wind-pollinated flowers.
- d
 - 1 The anthers are outside the flower. *insect-pollinated flowers / wind-pollinated flowers*
 - 2 The stigmas are outside the flower. *insect-pollinated flowers / wind-pollinated flowers*
 - 3 The stigmas are small. *insect-pollinated flowers / wind-pollinated flowers*
 - 4 The stigmas are inside the flower. *insect-pollinated flowers / wind-pollinated flowers*
 - 5 The stigmas are pinnate (feathery). *insect-pollinated flowers / wind-pollinated flowers*
- e Figure 7 shows the flowers of five different plants.
 - 1 Which plants have insect-pollinated flowers? *A / B / C / D / E*
 - 2 Which plants have wind-pollinated flowers? *A / B / C / D / E*

fig. 7



4

Summary
Make a summary of this Basics section.

- Pollination:
- Self-pollination:
- Cross-pollination:

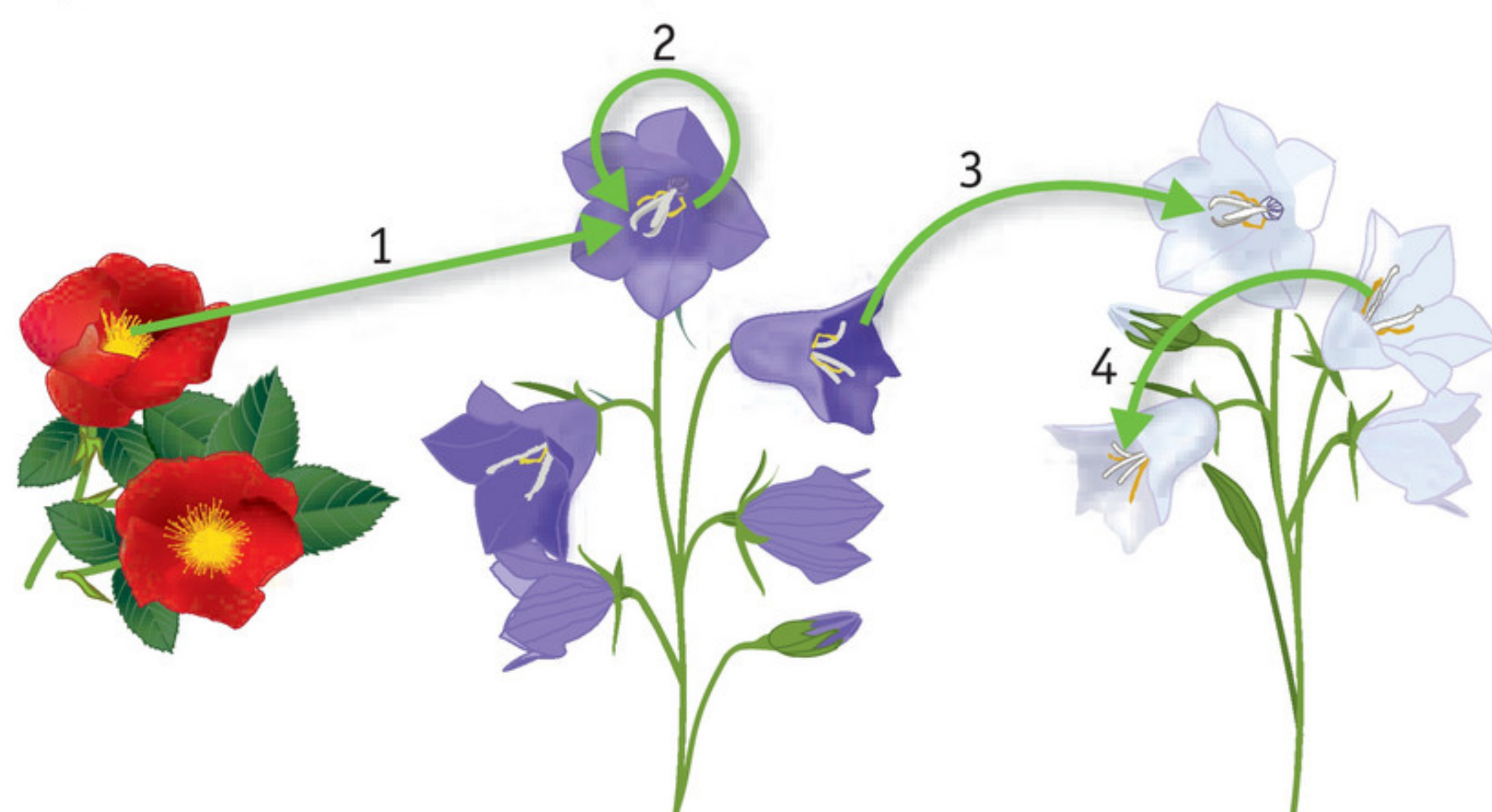
	Insect-pollinated flowers	Wind-pollinated flowers
Flowers		
Scent		
Anthers		
Petals		
Nectar		
Stigma		
Pollen		

INSIGHT

5

Figure 8 shows a rose, two campanulas and four different situations. For each situation, say what is happening: no pollination, self-pollination or cross-pollination. Explain your answer.

fig. 8 A rose and two campanulas.

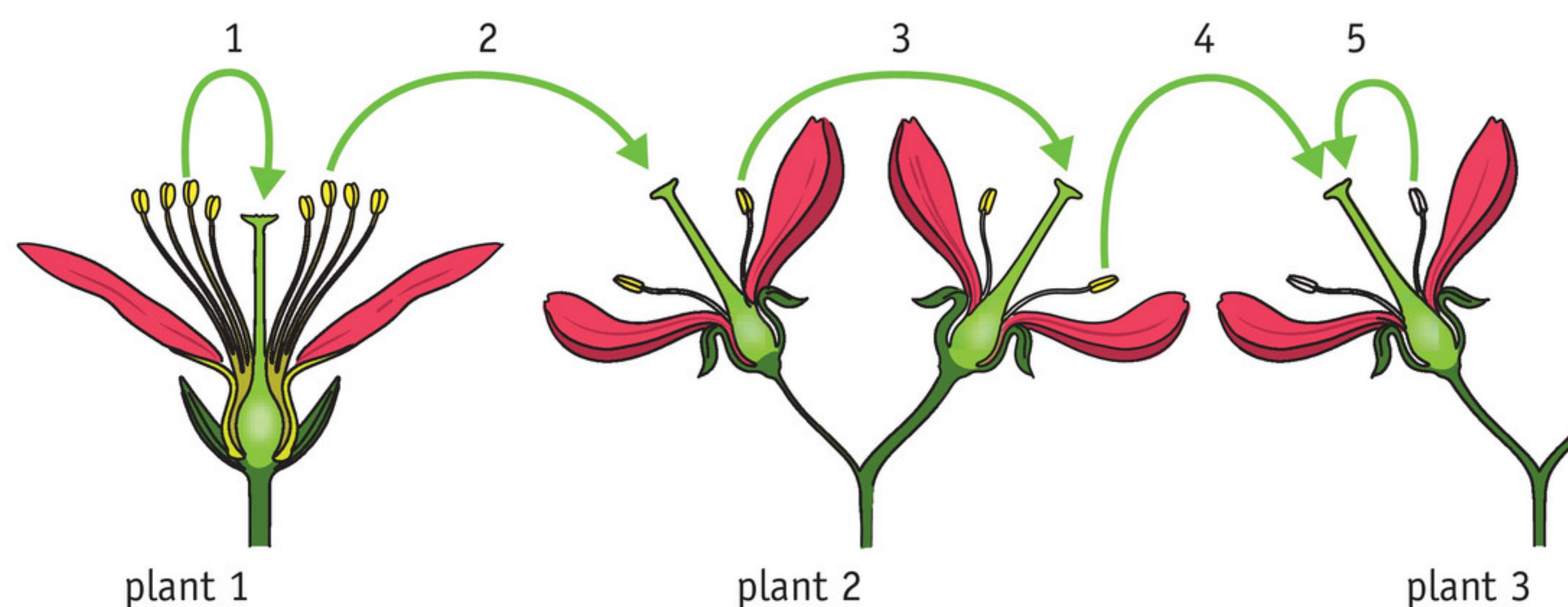


6

Figure 9 shows the flowers of three plants. Plants 2 and 3 are the same species. The transfer of pollen is shown with arrows.

- Which number or numbers show self-pollination? 1 / 2 / 3 / 4 / 5
- Which number or numbers show cross-pollination? 1 / 2 / 3 / 4 / 5
- Which number or numbers show no pollination? 1 / 2 / 3 / 4 / 5

fig. 9



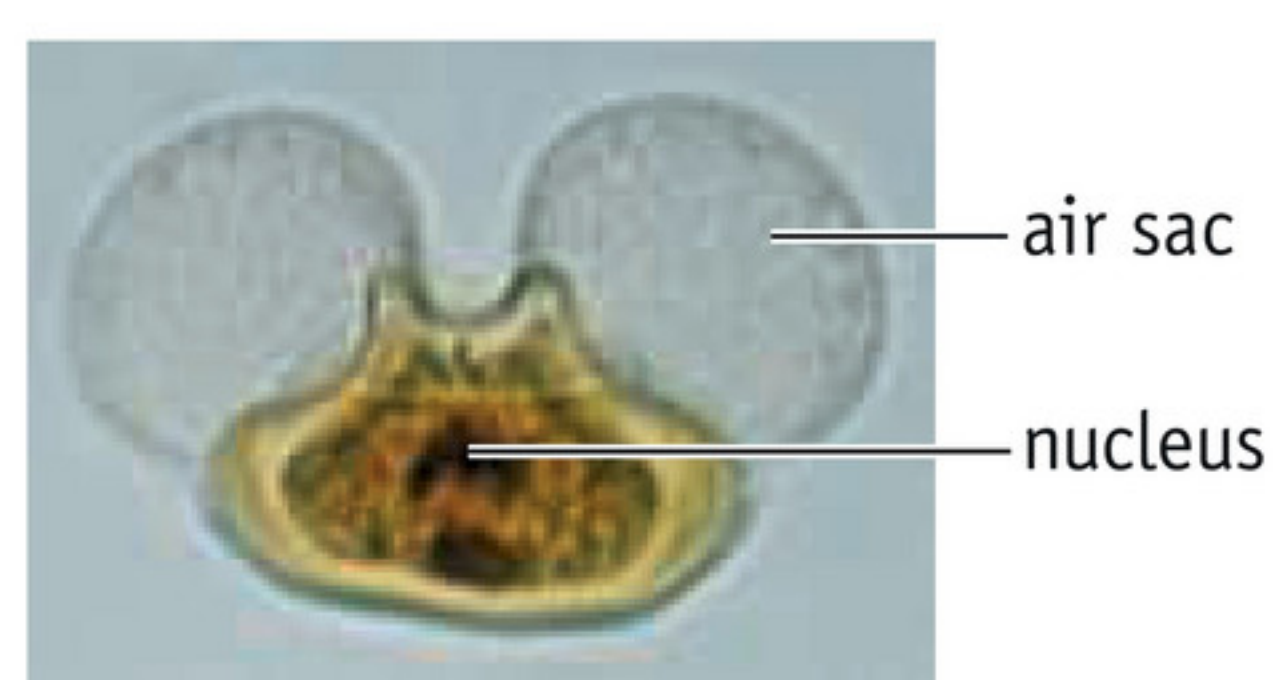
7

Figure 10 shows you the flowers of a foxglove. The nectar is deep inside the flowers, so that insects cannot get to it easily. What advantage does this have for these plants?

fig. 10 Foxglove.



fig. 11 Pine pollen grain.



8

Figure 11 is a photo of a pollen grain from a pine tree.

- a Is the pollen of pine trees spread by insects or by the wind? Explain your answer.
- b The pollen grains of insect-pollinated flowers are usually rough and sticky; pollen grains of wind-pollinated flowers are smooth and lightweight.
What is the advantage of this?

+ 9

‘Ripe’ stamens and carpels are fully grown and ready for pollination. The stamens in some plant species ripen earlier than the carpels.
How does this affect the pollination?

HOW IT FITS TOGETHER science

POLLINATION BY BATS

Fruit bats pollinate over five hundred plant species, mostly tropical ones. These are bats that do not eat insects but instead eat nectar, pollen and overripe, rotting fruit. The latter in particular is unusual because rotting fruit can contain a lot of alcohol. In people, alcohol reduces the ability to react. Canadian researchers studied its effect on bats. They gave one group of bats sugar water and the other group sugar water with alcohol. They then released the test animals in a flight cage with obstacles. All the bats cleared the obstacles without any difficulty. The alcohol did not affect them.

The flowers of plants pollinated by bats can be found at easily accessible places on trees or shrubs. They are large, have a large amount of pollen and are only open at night. The flowers do not have striking colours but do often have a somewhat musty, sulphurous scent.

fig. 12 A bat and an agave flower.



10

Read the text about “Pollination by bats”.

The Canadian researchers gave the bats sugar water.

- a What substance in the flowers resembles sugar water?
- b Explain why flowers pollinated by bats do not need striking colours.
- c Not only insects and bats but also birds and even mammals such as mice can pollinate flowers. Despite this, flowers are usually classified as either wind-pollinated flowers or insect-pollinated flowers.
Are bat-pollinated flowers more like wind-pollinated flowers or insect-pollinated flowers? Explain your answer.
- d Explain why bat-pollinated flowers often spread a musty, sulphurous scent.

 Go to the *Flash cards* and the *Test yourself* section.

3 Fertilization

LEARNING OBJECTIVES

- 6.3.5 You can describe the fertilization process in seed plants.
- 6.3.6 You can describe the change in the ovule after fertilization.
- Practical activity 6

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES				
	6.3.5	6.3.6	6.1.1*	6.2.2*	6.2.3*
Remembering	1abc	3a			
Understanding	1d, 2, 4	3bcd, 4	10c		
Using	5bc, 10de	5d, 6, 7, 9a		5a, 10d	10a
Analysing	10b	8, 9b			

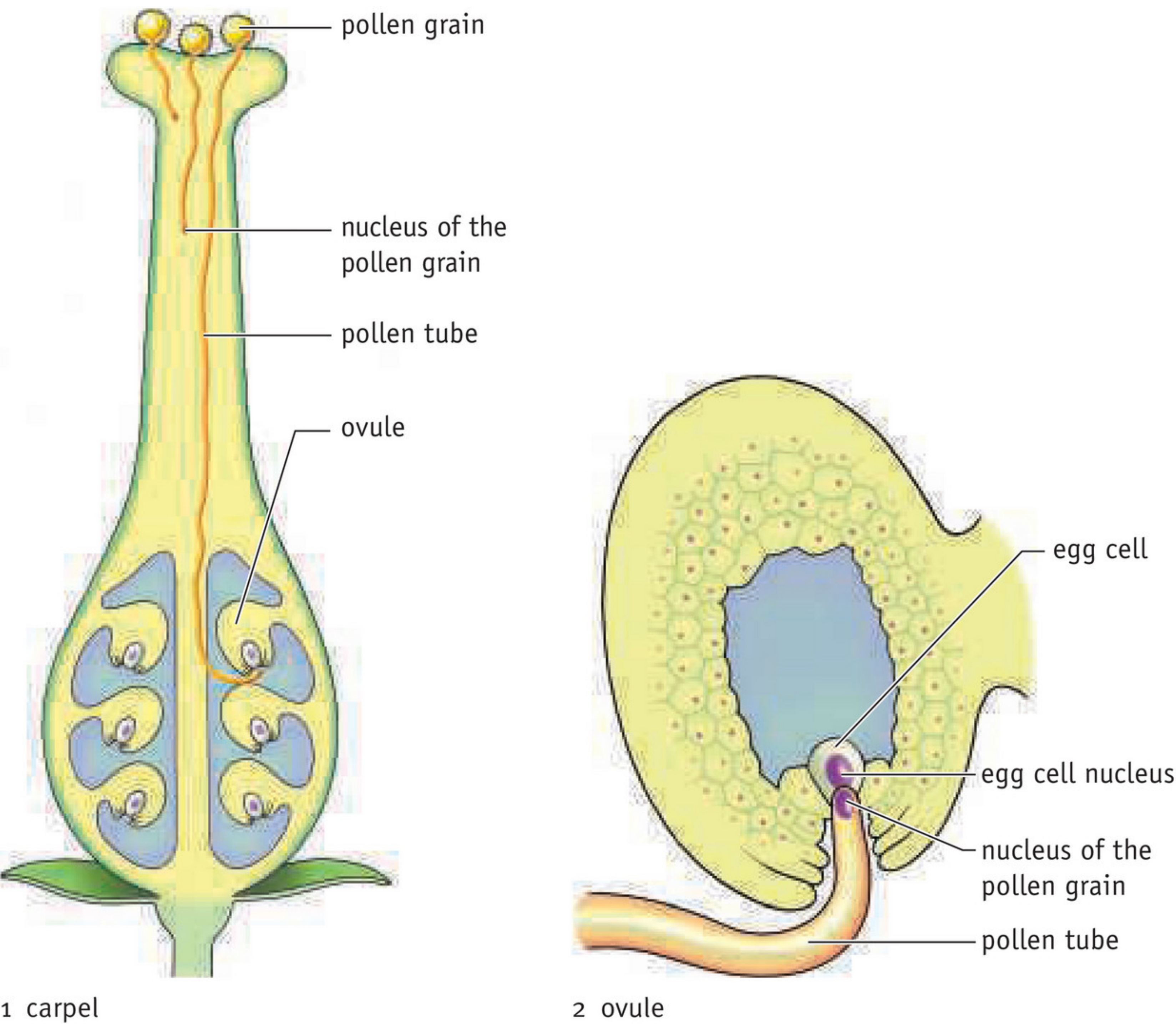
*You can find this learning objective in another Basics section.

After pollination, the nucleus of a pollen grain must get to the nucleus of the egg cell in the ovule. When they have fused, the first step in reproduction has succeeded.

POLLEN TUBE

Each ovule has an egg cell: a female sex cell. There is a nucleus in each egg cell. Pollen grains have nuclei too. When a pollen grain lands on the stigma of a plant of the same species, a tube starts to grow from it: the **pollen tube**. The pollen tube grows down the style to the ovule in the ovary (see figure 1.1). The nucleus of the pollen grain goes through the pollen tube to the ovule.

fig. 1 Fertilization.

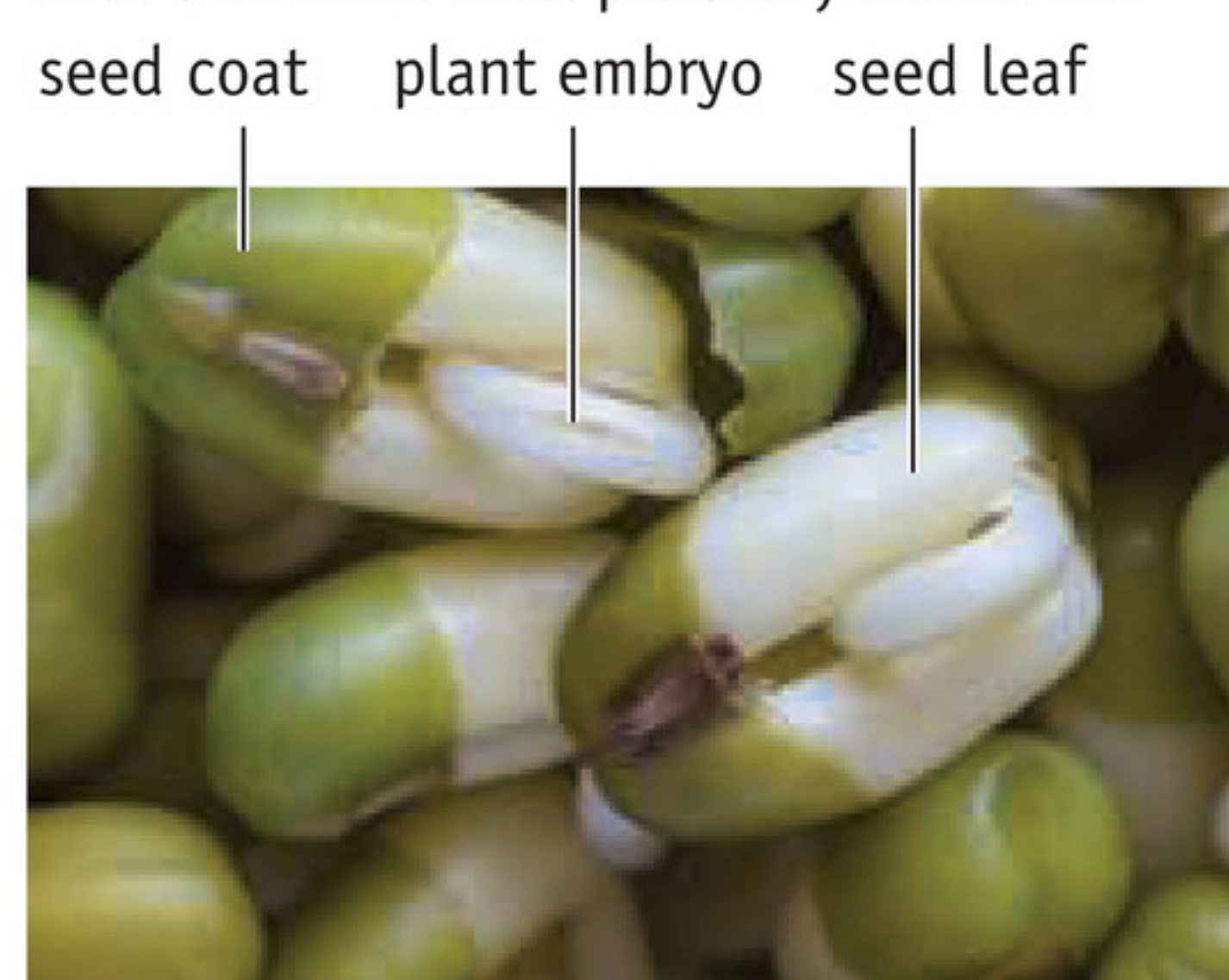


On reaching the ovule, the tip of the pollen tube breaks open.. The nucleus of the pollen tube penetrates the egg cell and fuses with the nucleus of the egg cell (see figure 1.2). This fusion of the nuclei of a male sex cell and a female sex cell is called **fertilization**. Fertilization produces an embryo. The nucleus of a plant embryo contains the chromosomes of both the male and female sex cells.

PLANT EMBRYO

After fertilization, the fertilized embryo starts to grow. A **plant embryo** grows by cell division. The ovule also starts to grow. The ovule turns into a **seed**. Each seed contains a germ or 'plant embryo' (see figure 2). When a seed germinates, the plant embryo grows into a seedling.

fig. 2 Germinating seeds (mung beans) with the seed coat partially removed.



In figure 1, you can see that several pollen tubes are growing down at the style at the same time. These pollen tubes will grow towards different ovules. The egg cell in each of these ovules can be fertilized. Every ovule with a fertilized egg cell can develop into a seed, so several seeds can form in a single ovary. If the egg cell in an ovule is not fertilized, that egg cell cannot grow to become an embryo. The ovule will then not grow to become a seed.

KNOWLEDGE

1

A pollen tube starts to grow from a pollen grain down to an ovule.

a Which parts of the carpel does the pollen tube grow through and in what sequence?

1

2

3

b What happens after the pollen tube enters the ovule? Describe this in three steps.

c What is fertilization?

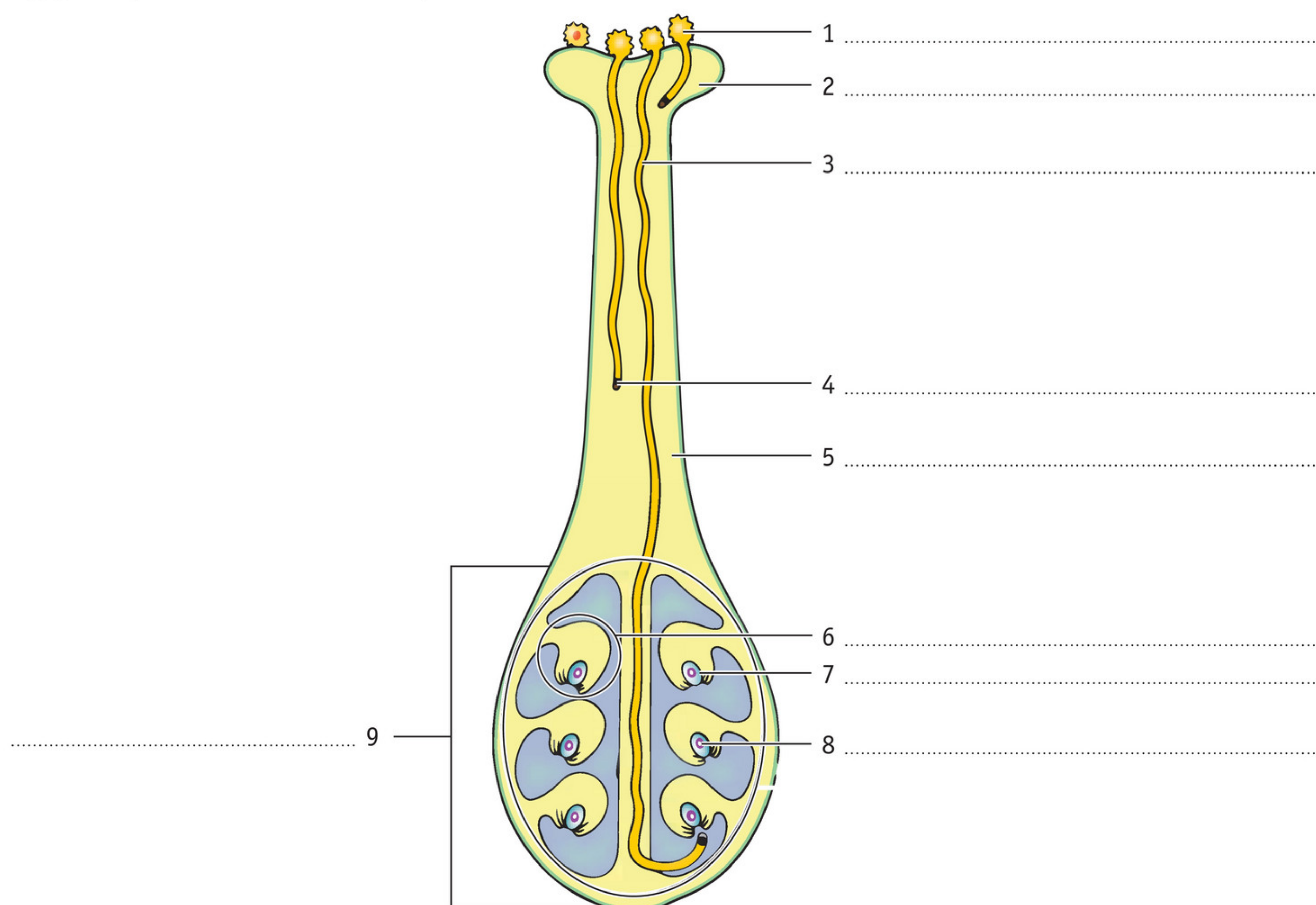
d What chromosomes does the cell nucleus in a fertilized ovum contain?

2

Figure 3 shows a longitudinal section of a carpel.

Write down the names next to the numbered parts.

fig. 3 Longitudinal section of a carpel.



3

- a** A (or germ) develops from a fertilized ovum.
- The ovule turns into a
- b** Does every egg cell in an ovary grow to become a plant embryo? Explain your answer.
- c** Does every ovule in an ovary grow to become a seed? Explain your answer.
- d** A plant embryo develops from a fertilized ovum.
- Does the nucleus of the plant embryo have the same chromosomes as the nucleus of the fertilized ovum? Explain your answer.

4

Summary

Make a summary of this Basics section.

- Describe the fertilization process in seed plants.
- Describe the changes in the ovule after fertilization.
- Describe how a seed grows into a seedling.

INSIGHT

5

Figure 3 shows a longitudinal section of a carpel.

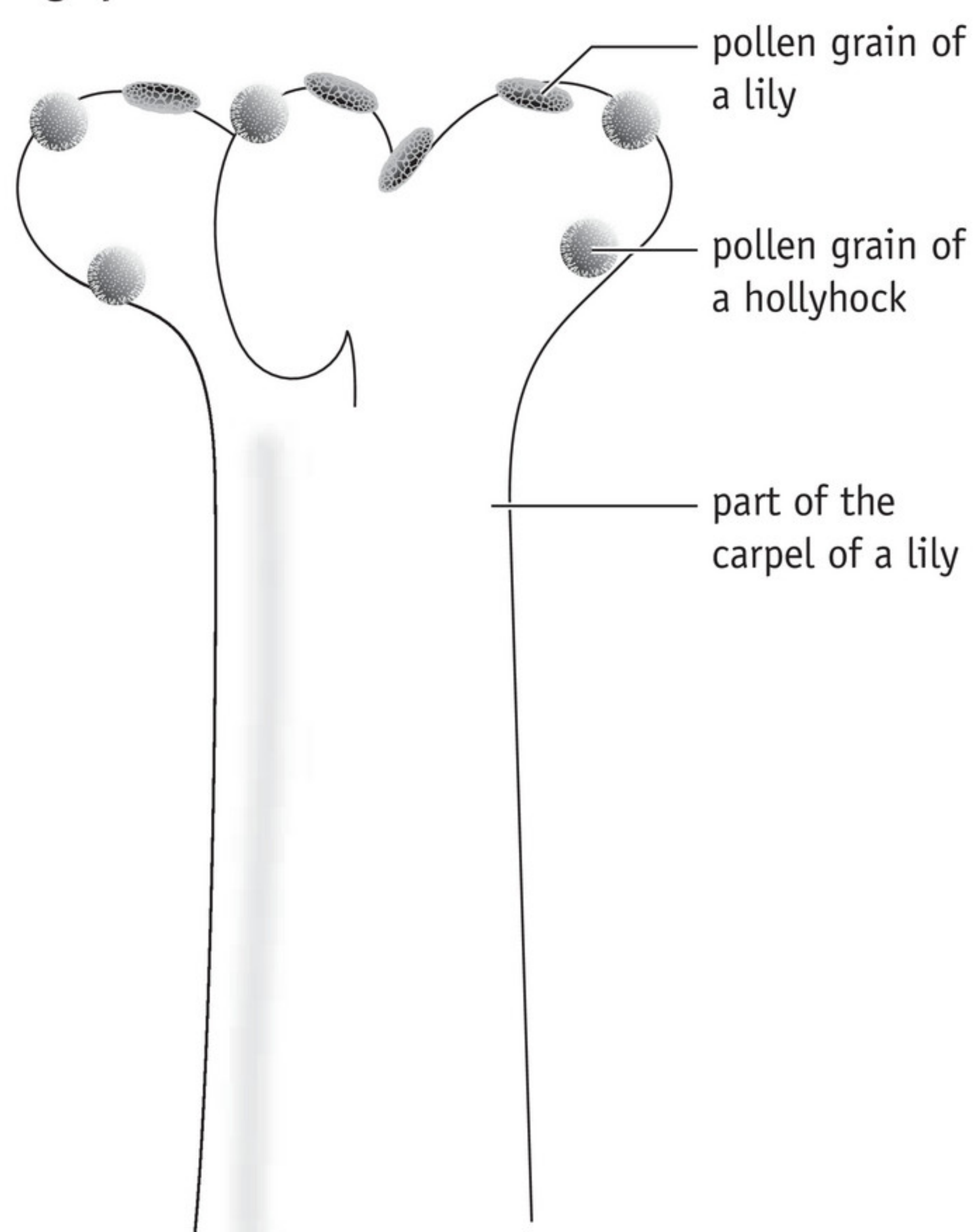
- a** Has pollination taken place in this carpel? Explain your answer.
- b** Has fertilization taken place in this carpel? Explain your answer.
- c** If no more pollen grains get in, a maximum of 1 / 3 / 4 / 6 ova can be fertilized in the carpel in figure 3.
- d** The ovary of this flower contains six ovules.
Suppose that the ova in three ovules get fertilized. How many seeds will develop in this ovary? Explain your answer.

6



Figure 4 shows part of the carpel of a lily with pollen grains on it.
Draw the pollen tubes in this carpel.

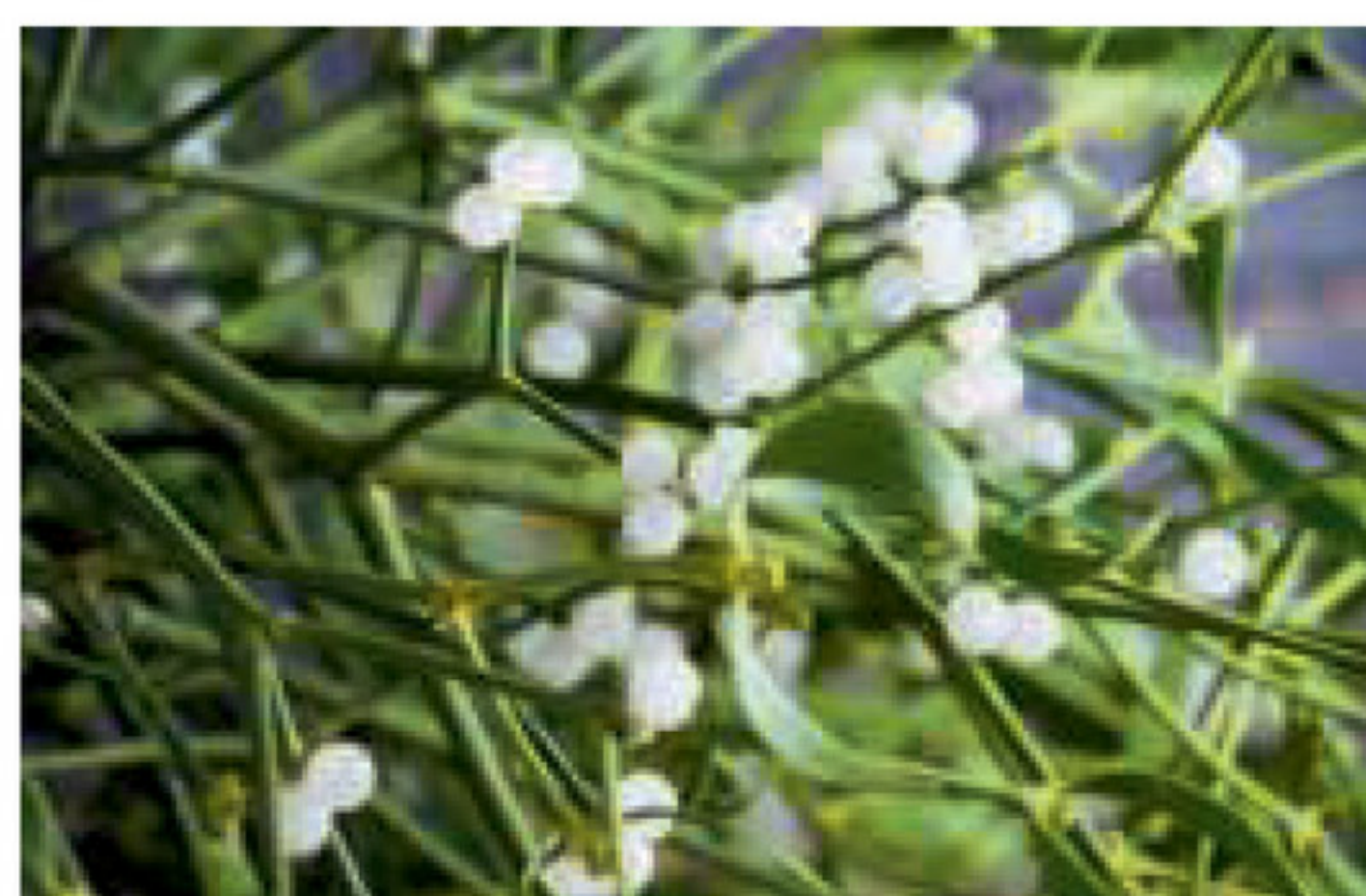
fig. 4



7

Mistletoe (see figure 5) is an unusual plant. In the Netherlands, it can only be found in Limburg. Mistletoe lives on tree trunks or branches, for instance of poplars. It grows berries in the autumn. Each flower produces a single berry.
Does a mistletoe flower have one carpel or could there be more? Explain your answer.

fig. 5 Mistletoe.



+ 8

Megan wonders why the seeds in tomatoes don't germinate while the fruits are still attached to the plant.

a What could be an explanation for this?

- ☐ A A tomato does not contain food reserves for the plant embryo.
- ☐ B A tomato has substances that inhibit germination.
- ☐ C Light is needed for the tomato seeds to germinate.
- ☐ D Water is needed for the tomato seeds to germinate.

b Figure 6 shows you various tomato varieties.

Can these different tomatoes grow from the same plant? Explain your answer.

fig. 6 Various tomato varieties.



fig. 7 A pumpkin with seeds.



+ 9

Figure 7 shows a cross-section of a pumpkin with seeds.

a Did these seeds grow in the same ovary? Explain your answer.

b Do pumpkin seeds have the same chromosomes in the nucleus as the ovary where they grew? Explain your answer.

HOW IT FITS TOGETHER profession

PLANT BREEDER

Peter van de Pol is director of Schoneveld Breeding, a plant breeding company with branches in several different countries. Peter explains, "A plant breeder develops the exact plant that clients ask for. We cross plants to get new ones with new properties. This is called breeding. Our company specializes in breeding flowering potted plants, such as cyclamens. We create ornamental plants that are distinctive, with special leaves, flower shapes or colours. We harvest seed and pollen here. We use that pollen to pollinate the flowers of other plants. This is done very carefully with a brush. We also have to wash our hands regularly and there is insect netting everywhere. After the pollination and fertilization, the plants produce seeds that we sow it to see what the properties of the offspring are. We cross the best and most attractive offspring further until we get a plant that meets the client's wishes in full."

fig. 8 Plant breeder Peter van de Pol.



10

Read the text about a “Plant breeder”.

Peter wants to cultivate a new variety of cyclamen from two existing cyclamen varieties.

- a** Will he use cross-pollination or self-pollination? Explain your answer.
- b** Figure 8 shows Peter with white, red and pink cyclamens.
Explain how you might be able to “make” a pink cyclamen from white and red ones.
- c** In breeding, you don’t want flowers to get fertilized by pollen from other plants in the greenhouse. The greenhouse therefore has special zones where the male sex organs have been removed from the flowers.

What part does Peter remove from these flowers?

- ☐ A The sepals
 - ☐ B The petals
 - ☐ C The stamens
 - ☐ D The carpel
 - ☐ E The ovary
 - ☐ F The ovule
- d** When does Peter remove the male sex organs: before or after they are mature?
Explain your answer.
 - e** Insect netting has been fitted throughout the greenhouses. Insect netting prevents insects from getting in the greenhouse.
Explain why breeders do not want insects in their greenhouses.

 Go to the *Flash cards* and the *Test yourself* section.

4 Fruits and seeds

LEARNING OBJECTIVE

6.4.7 You can describe the changes in the ovary after fertilization.

► Practical activity 7

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	6.4.7	6.1.1*	6.3.5*
Remembering	1a		
Understanding	1b, 2, 3, 9ae	9e	
Using	4, 5, 7, 8ab, 9d		8a
Analysing	6, 8cd, 9bc		

* You can find this learning objective in another Basics section.

After fertilization, one or more seeds appear in the ovary. The ovary is the start of a fruit. Fruits come in lots of different shapes and sizes.

A FRUIT

A great deal changes in a flower after fertilization. One or more ovules in the ovary start to grow. Only the ovules in which the ova have been fertilized grow into seeds. The other ovules in the ovary shrivel away. The ovary gets bigger. It grows to become a fruit. The seeds are in the fruit.

Figure 1 shows the changes in a flower of a bean plant. The fruits of bean plants are called pods (see figure 2).

- 1 the flower before fertilization
- 2 After fertilization, the ovules and the ovary start to grow.
- 3 The petals and stamens fall off; the ovary begins to lengthen.
- 4 The calyx withers, leaving just a remnant. Only a remnant of the style remains; the ovules become larger.
- 5 When the bean is ripe, the seed coats become darker. Eventually, the fruit bursts and the seeds are released.

fig. 1 Changes in the flower of bean plant after fertilization.

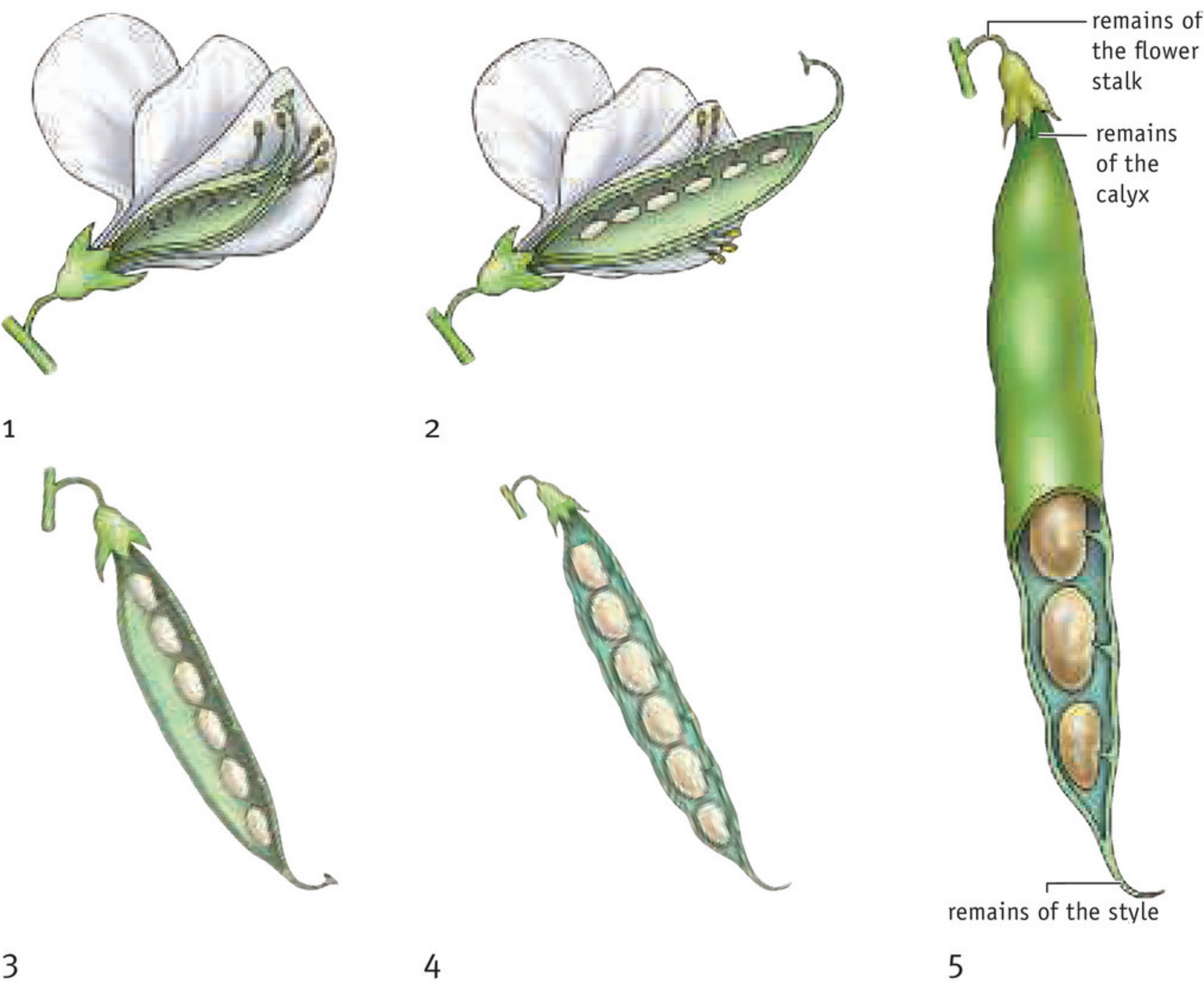


fig. 2 Pods of the scarlet runner bean.



The flower of a French bean is on a stalk. The weight of the bean means that the fruit will hang down from that stalk. The petals and the stamens have dropped off. A remnant of the calyx remains at the stalk end. The remains of the style are at the other end of the French bean.

VARIOUS FRUITS

Some fruits contain **pulp**, the soft and sometimes edible part. Pulp can develop from the ovary or the flower receptacle. Figure 3 shows you the development from flower to fruit in an apple. Figure 4 shows you the development from flower to fruit in an orange and a banana.

fig. 3 Development from flower to fruit in an apple.

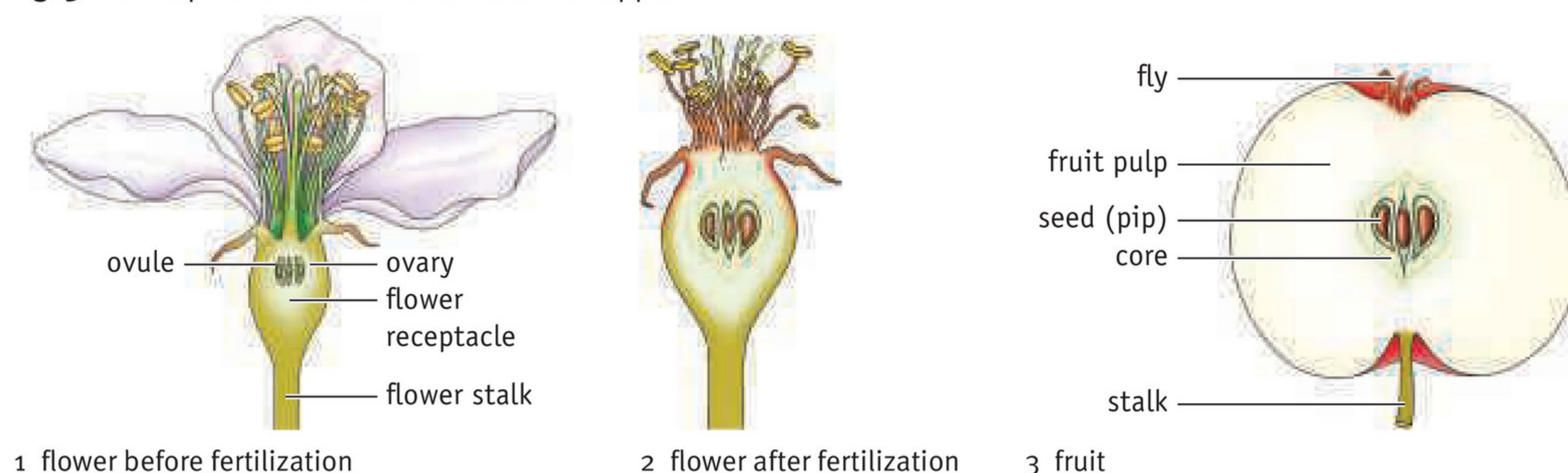
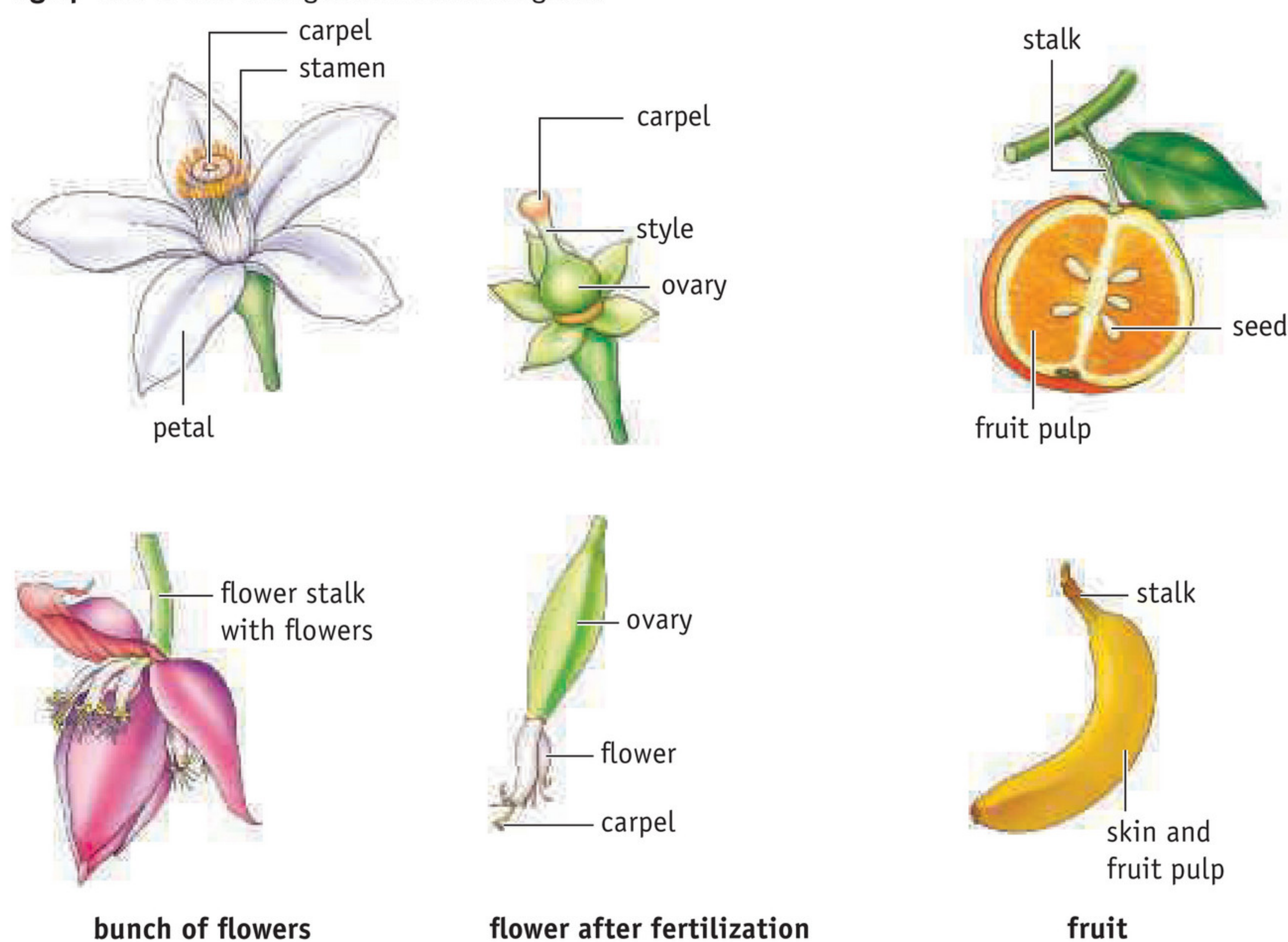


fig. 4 This is how oranges and bananas grow.



Apples, cherries, tomatoes and pods are all fruits. Beans, peas, apple and tomato pips and cherry stones are all seeds. Some fruits contain a single seed; others contain a large number (see figure 5). One melon can contain over a hundred seeds. Each of these seeds requires the nucleus of an egg cell to have fused with the nucleus of a pollen grain.

fig. 5 Fruits with seeds.



1 plum: one seed



2 apples and pears: several seeds



3 pepper: lots of seeds



4 tomato: lots of seeds



5 melon: lots of seeds

The pulp of many fruits is eaten by humans and animals. Many seeds are also edible. A seed contains a reserve of food for the seedling that can develop from the plant embryo. This reserve can also be food for animals and humans (see figure 6).

fig. 6 Edible seeds.



KNOWLEDGE

1

a What happens to the parts of a flower after fertilization?

- 1 calyx *grows / falls off / withers*
- 2 petal *grows / falls off / withers*
- 3 stamen *grows / falls off / withers*
- 4 style *grows / falls off / withers*
- 5 ovary *grows / falls off / withers*
- 6 ovule *grows / falls off / withers*

b Five changes in the flower of pear tree are listed below. Put the changes in the correct sequence.

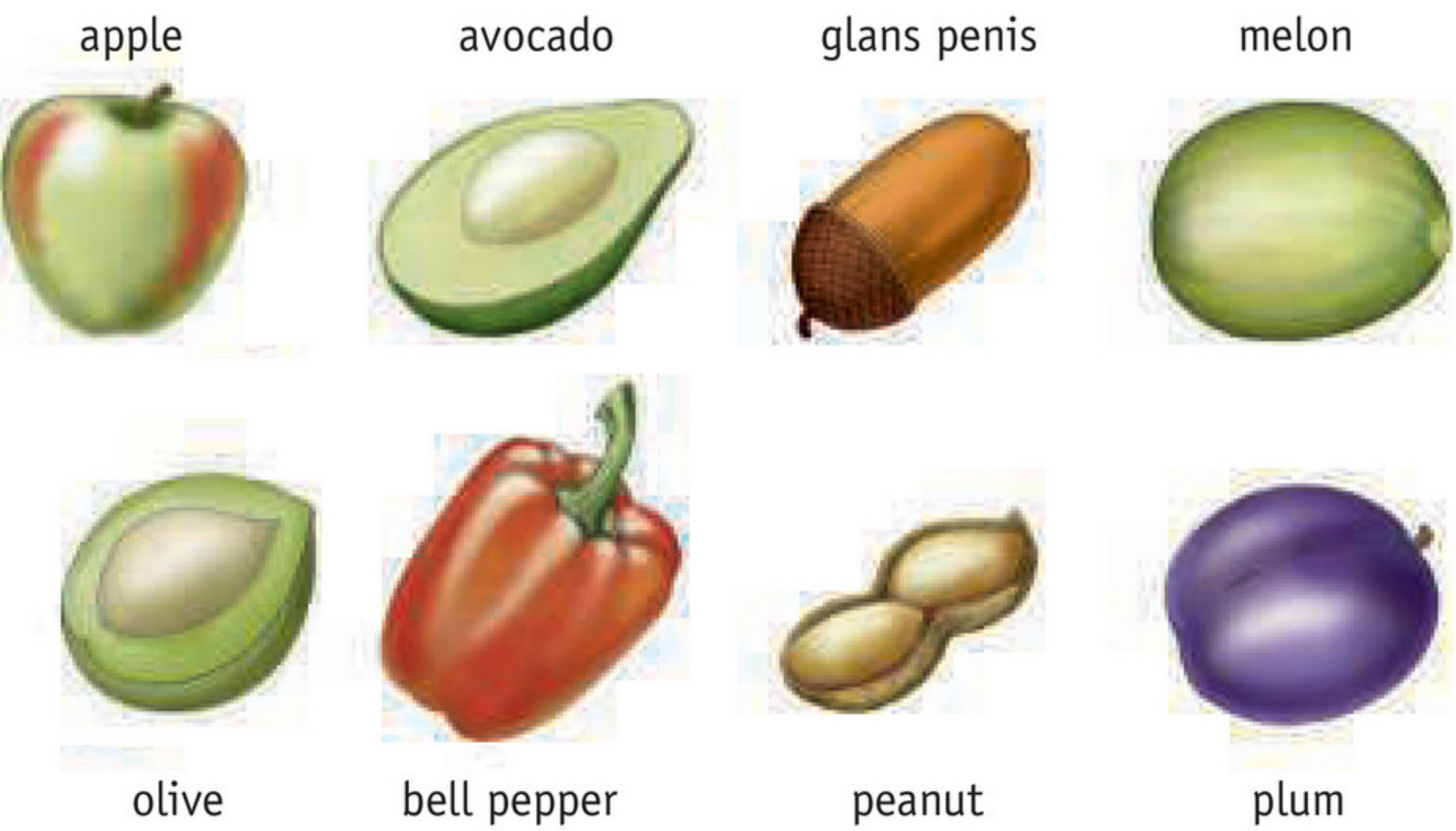
- The calyx and style shrivel away.
- The ovules and the ovary start to grow.
- The pear is ripe.
- The flower is fertilized.
- The petals and stamens fall off.

2

Figure 7 shows you eight fruits.
Which fruits come from ovaries with a single ovule?

- ☐ A apple
- ☐ B avocado
- ☐ C acorn
- ☐ D melon
- ☐ E olive
- ☐ F pepper
- ☐ G peanut
- ☐ H plum

fig. 7



3



Summary

Make a summary of this Basics section.
Changes in a flower after fertilization:

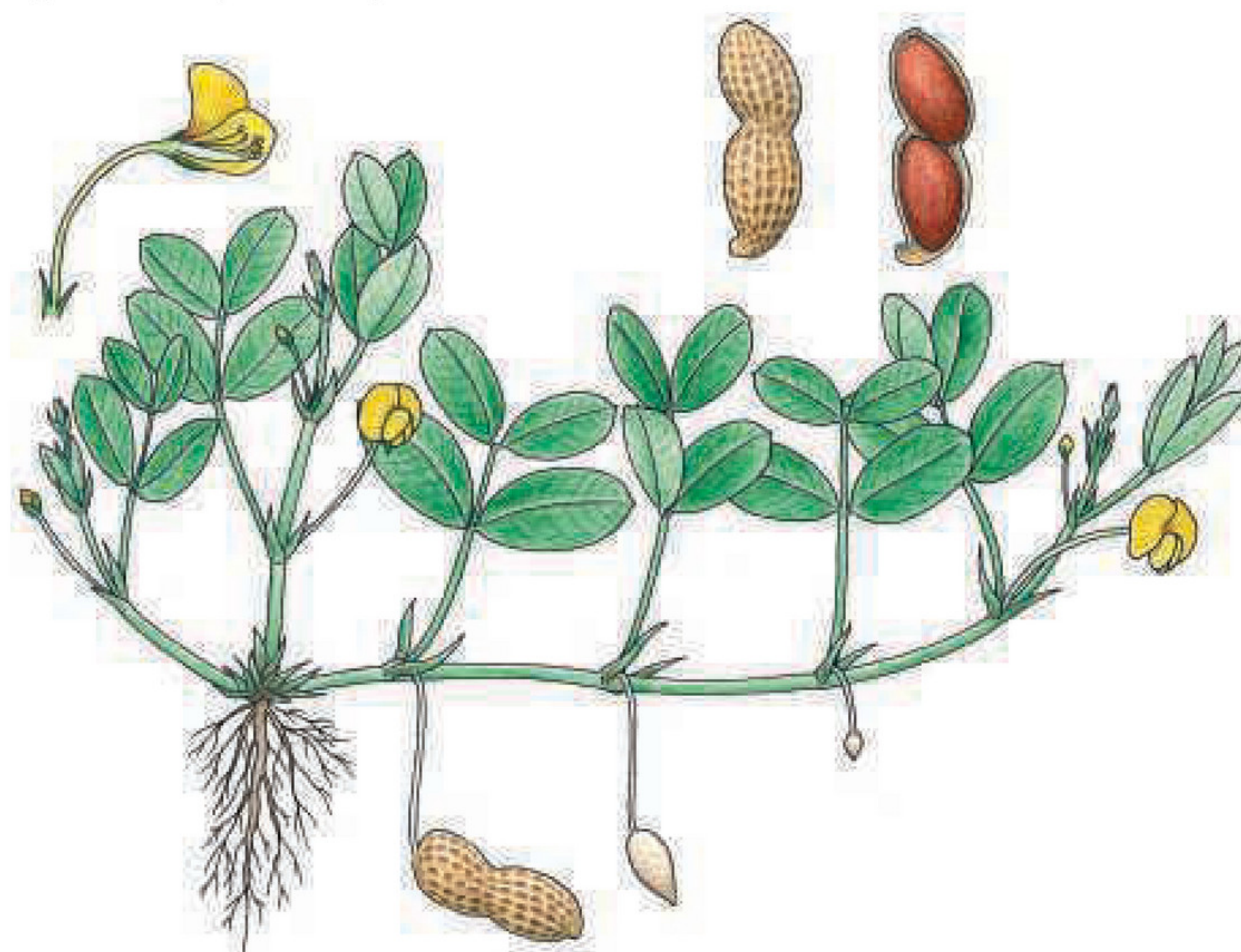
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-
-

INSIGHT

4

Peanuts grow on a peanut plant (see figure 8). A peanut shell (the pod or fruit) has two peanuts.
Suppose someone eats eighteen peanuts. How many of the following parts were needed for eighteen peanuts?
2 / 9 / 18 pollen grains
2 / 9 / 18 ovaries
2 / 9 / 18 ovules
2 / 9 / 18 ova

fig. 8 Peanut plant with peanuts.



5

In a pear, the core and the pulp develop in the same way as in an apple.

- 1 The core of a pear grew from the *flower receptacle / ovary*.
- 2 The pulp of a pear grew from the *flower receptacle / ovary*.

6

Seeds from plants with berries can land in gutters and germinate there.

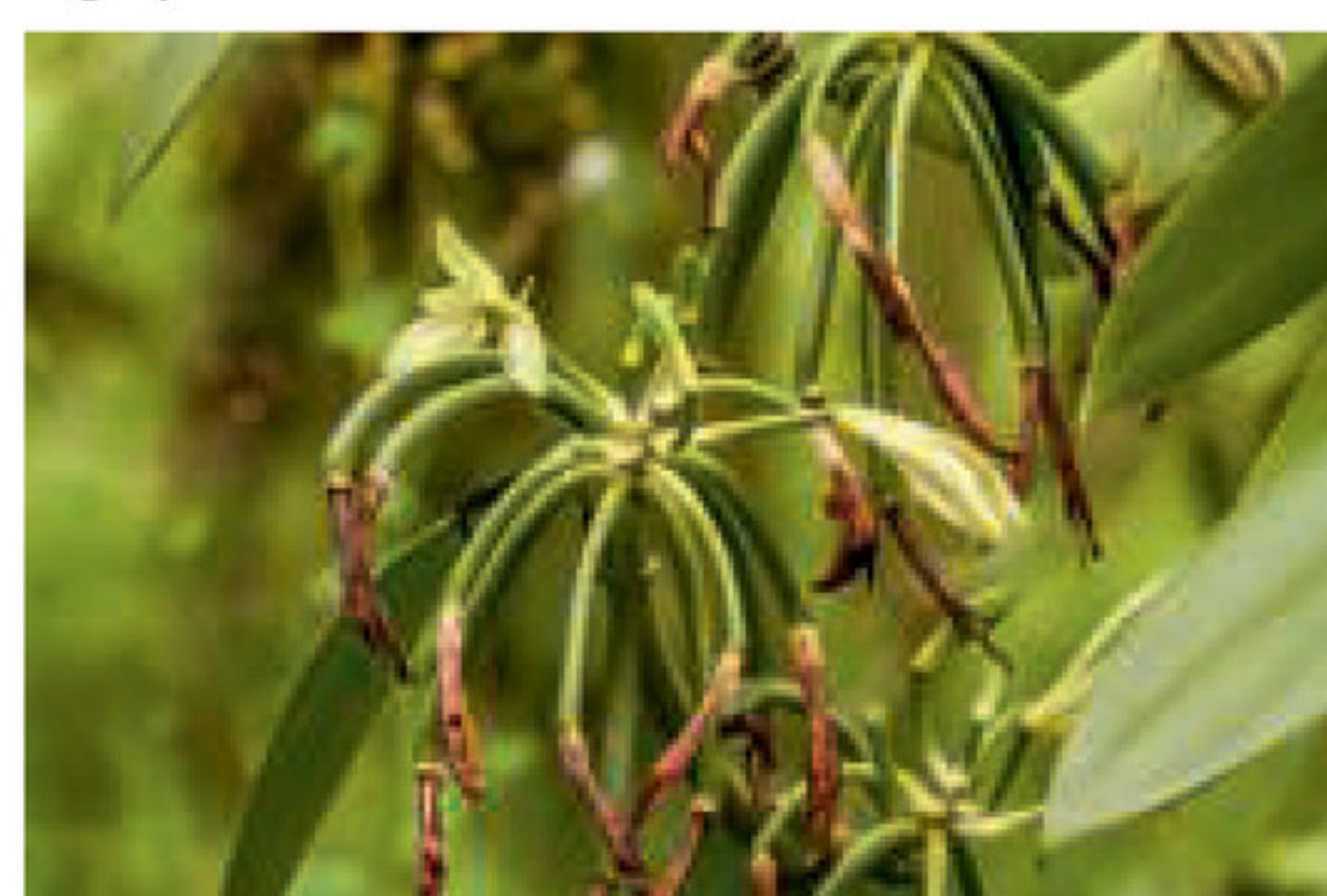
- a Explain how the seeds got there.
- b What is the function of the flesh of the fruit in seed dispersal?

7

Figure 9 shows a vanilla flower with vanilla pods next to two dried vanilla pods. A vanilla pod contains an average of 1500 seeds.

- a How many carpels did the two vanilla pods come from? Explain your answer.
- b How many ovules did the seeds in two fruits come from? Explain your answer.

fig. 9 Vanilla.



1 vanilla flower with vanilla pods



2 dried vanilla pods

+ 8

Table 1 shows the results of a study. The question was “Does the presence of bees affect the size of the apples?”

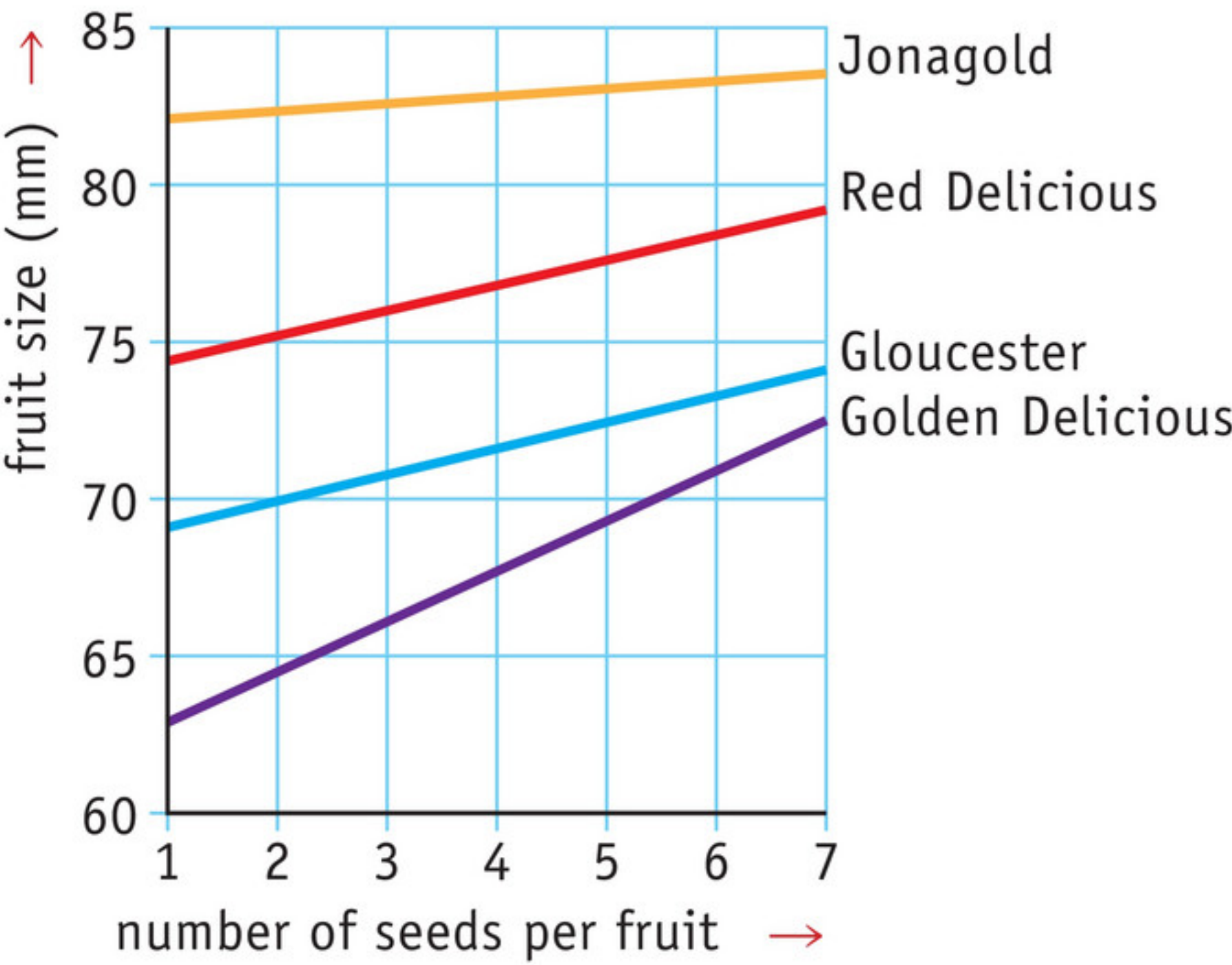
- a The increase in bee numbers increases the number of seeds per apple. Explain why.
- b Study the diagram in figure 10.
Do the apples get larger or smaller as the number of seeds in each apple increases, or is there no difference? *no difference / larger / smaller*
- c Use table 1 and figure 10 to explain why apple harvests can be increased by putting beehives in the orchard.
- d Which apple variety would it be best for a grower to use if they do not put beehives in the orchard? Explain your answer using figure 10.

Table 1 Results from the study (1).

Number of seeds per apple	Orchard A with 3 beehives	Orchard B with no beehives within 500 metres
	Proportion of potato harvest (%)	Proportion of potato harvest (%)
0	7	42
1	16	42
2	23	12
3	30	4
4	18	1
5	6	0

After: Mantiger (1998), Einfluss der Bestäubungsintensität durch Bienen auf die Anzahl Samen pro Frucht.

fig. 10 Result of the study (2).



After: Samenzahl und Fruchtgrösse (from Sonderdruck zur Interpoma 1998 des Südtiroler Imkerbundes).

HOW IT FITS TOGETHER the living world**THE STRAWBERRY**

Strawberries are one of the top five most widely eaten fruits. Well, not biologically: strawberries are in fact ‘false fruits’ or ‘accessory fruits’. That means that other parts than the ovary play a role in forming the fruit. The pulp of a strawberry grows from the flower receptacle. The pips you see on the outside came from ovaries.

Strawberries are healthy for you because they contain a lot of vitamin C and not many calories. Strawberries can only be kept for a few days, preferably still with their crowns attached. After that, they begin to go mouldy.

fig. 11**9**

Read the text about “The strawberry”.

- a** What is a false fruit (accessory fruit)?
- b** What are the real fruits of a strawberry plant?
- c** Where can you find the seeds of a strawberry plant?
- d** Do strawberry flowers have one carpel or several? Explain your answer.
- e** Where did the crown of the strawberry come from?

 Go to the *Flash cards* and the *Test yourself* section.

5 Asexual reproduction

LEARNING OBJECTIVES

- 6.5.8 You can explain that the offspring in asexual reproduction have the same hereditary characteristics as the parent.
- 6.5.9 You can give examples of asexual reproduction.
- Practical activity 8

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES				
	6.5.8	6.5.9	6.2.2*	6.2.4*	6.3.5*
Remembering		1ab			
Understanding	2, 4, 10b	1c, 3, 4, 10a			
Using	6a, 8a	5a, 6a			10c
Analysing	6b, 7, 8bc, 9	5b, 6b	10d	10d	

*You can find this learning objective in another Basics section.

Seed plants reproduce using pollen grains and ova. They can also reproduce without fertilization.

A NEW PLANT

A seed develops from an ovule with a fertilized egg cell. When fertilization is involved in reproduction, we call it **sexual reproduction**. In seed plants, sexual reproduction takes places when the nucleus of a pollen grain fuses with the nucleus of an egg cell. Seed plants can also reproduce without fertilization. In that case, part of the parent plant grows into a new plant. This is known as **asexual reproduction**. You can see an example of this in figure 1. In this plant, small plantlets are growing at the edges of the leaves. When these plantlets fall off and land on the ground (soil), each of them is capable of growing to become a new plant.

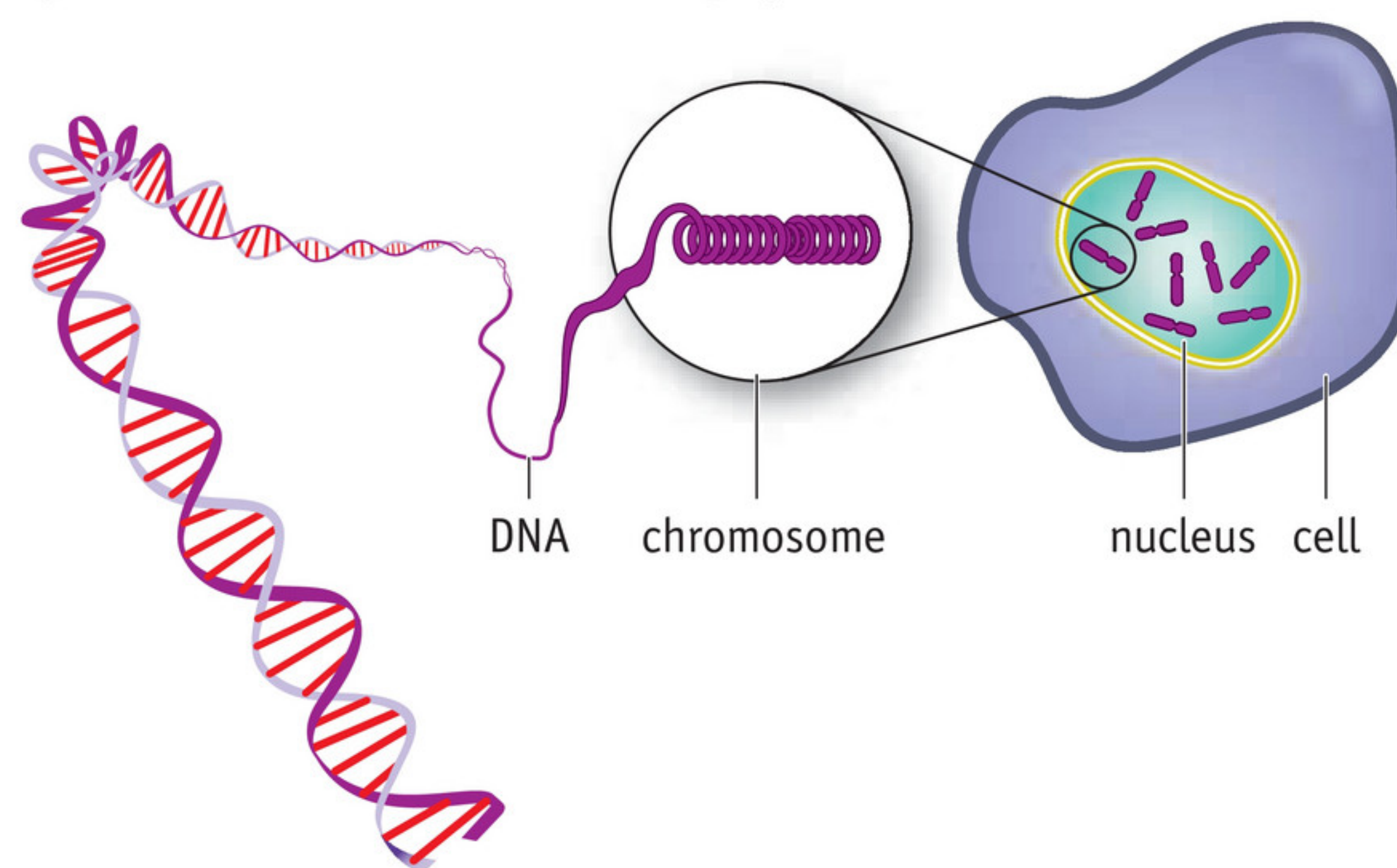
fig. 1 Kalanchoe daigremontiana (“Mother of Thousands”).



CELL DIVISION

All the cells of an organism have the same chromosomes in the nucleus. Chromosomes consist largely of DNA (see figure 2). The DNA contains the information for all hereditary characteristics.

fig. 2 A chromosome consists largely of DNA.



When a plantlet falls from the leaf margin and starts to grow, its cells start dividing. In cell division, the chromosomes in the nucleus are first copied. Then the cell divides into two daughter cells. Each daughter cell gets a complete set of chromosomes. So all the cells of the new plant have the same chromosomes as the parent plant.

In asexual reproduction, the offspring have exactly the same hereditary characteristics as the parent.

TUBERS

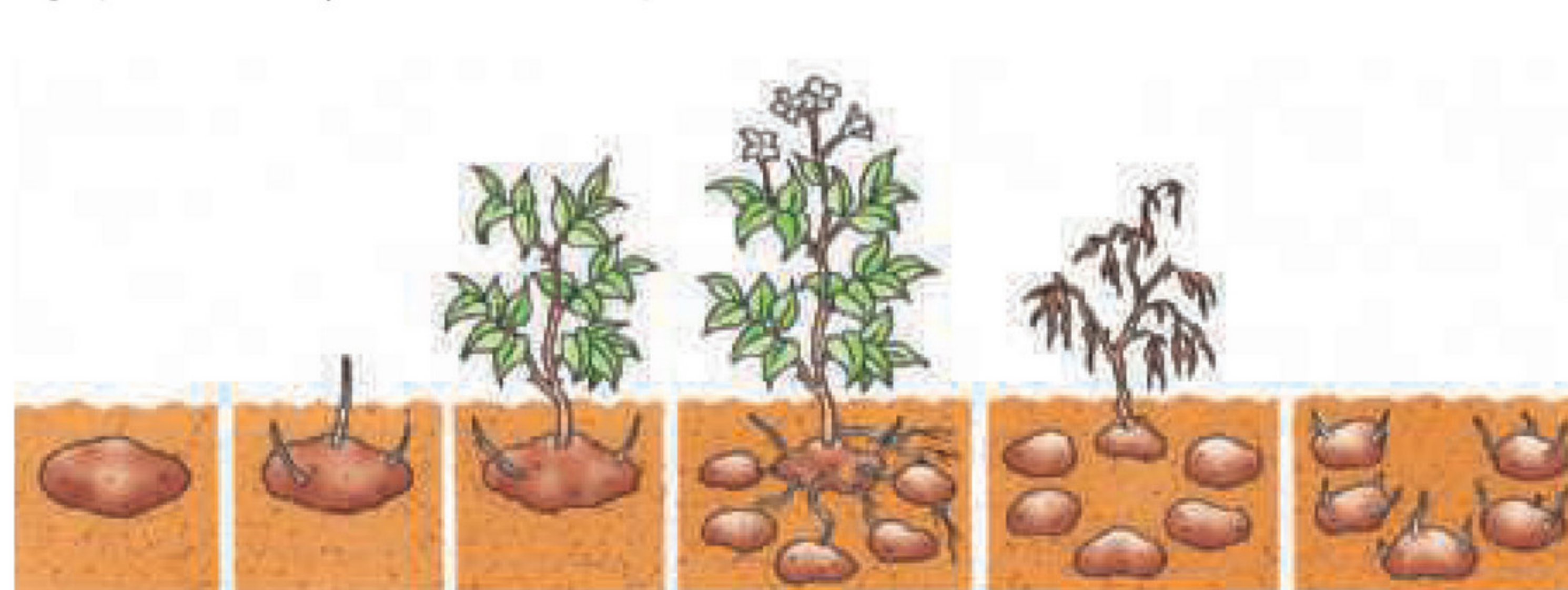
In potato plants, asexual reproduction takes place through **tubers**. A tuber is a thickening in the stalk below the ground, containing a large food reserve. A potato is a tuber (see figure 3).

A tuber has **buds**. In the case of a potato, the buds are called 'eyes'. In the spring, the buds start to grow. Each individual bud can produce a potato plant (see figure 4). Part of the plant grows into a new plant with the same hereditary characteristics as the parent.

fig. 3 Potato.



fig. 4 Asexual reproduction through tubers.



BULBS

Onions, daffodils and tulips are bulb crops. These are crops in which asexual reproduction takes place through **bulbs**. A bulb consists of roots – the **bulb base** (a very short stem) – and **food storage leaves** – thickened leaves with food reserves (see figure 5). There are buds between the storage leaves.

When a bulb starts to grow in the spring, a new plant grows from one of the buds. New bulbs grow from the other buds (see figure 6). The plant and the new bulbs have the same hereditary characteristics as the parent.

fig. 5 Cross-section of a bulb.

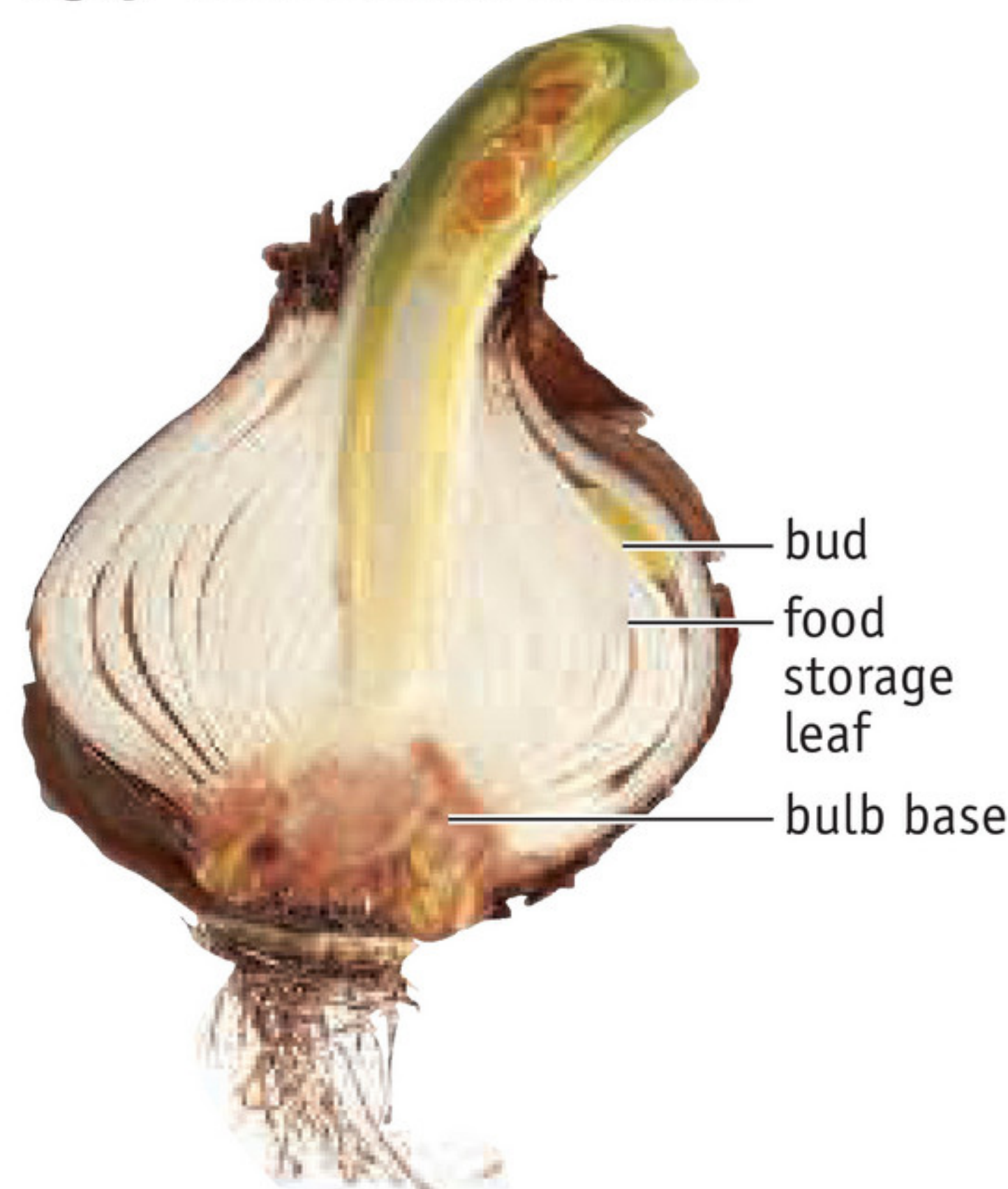
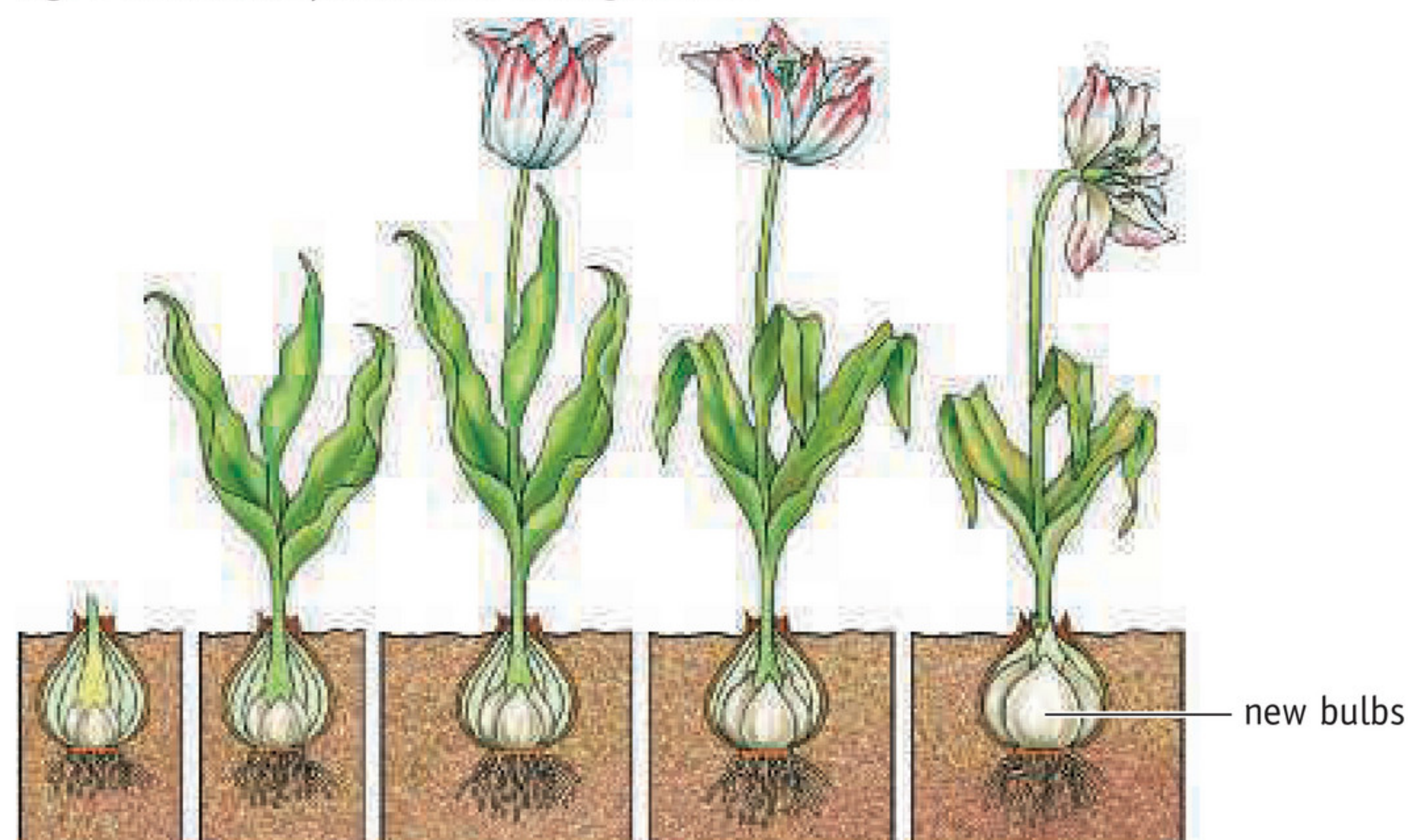


fig. 6 Asexual reproduction through bulbs.



RUNNERS AND RHIZOMES

Strawberry plants have **runners** (see figure 7). These are stems above ground that new plants can grow from at various places. This lets part of a strawberry plant (a young plantlet on a runner) grow into a new strawberry plant. In lily-of-the-valley, young plants can grow from runners that are roots rather than stems: these are called **rhizomes** (see figure 8). These are stalks below the ground that young plants can grow from.

fig. 7 Asexual reproduction through runners.

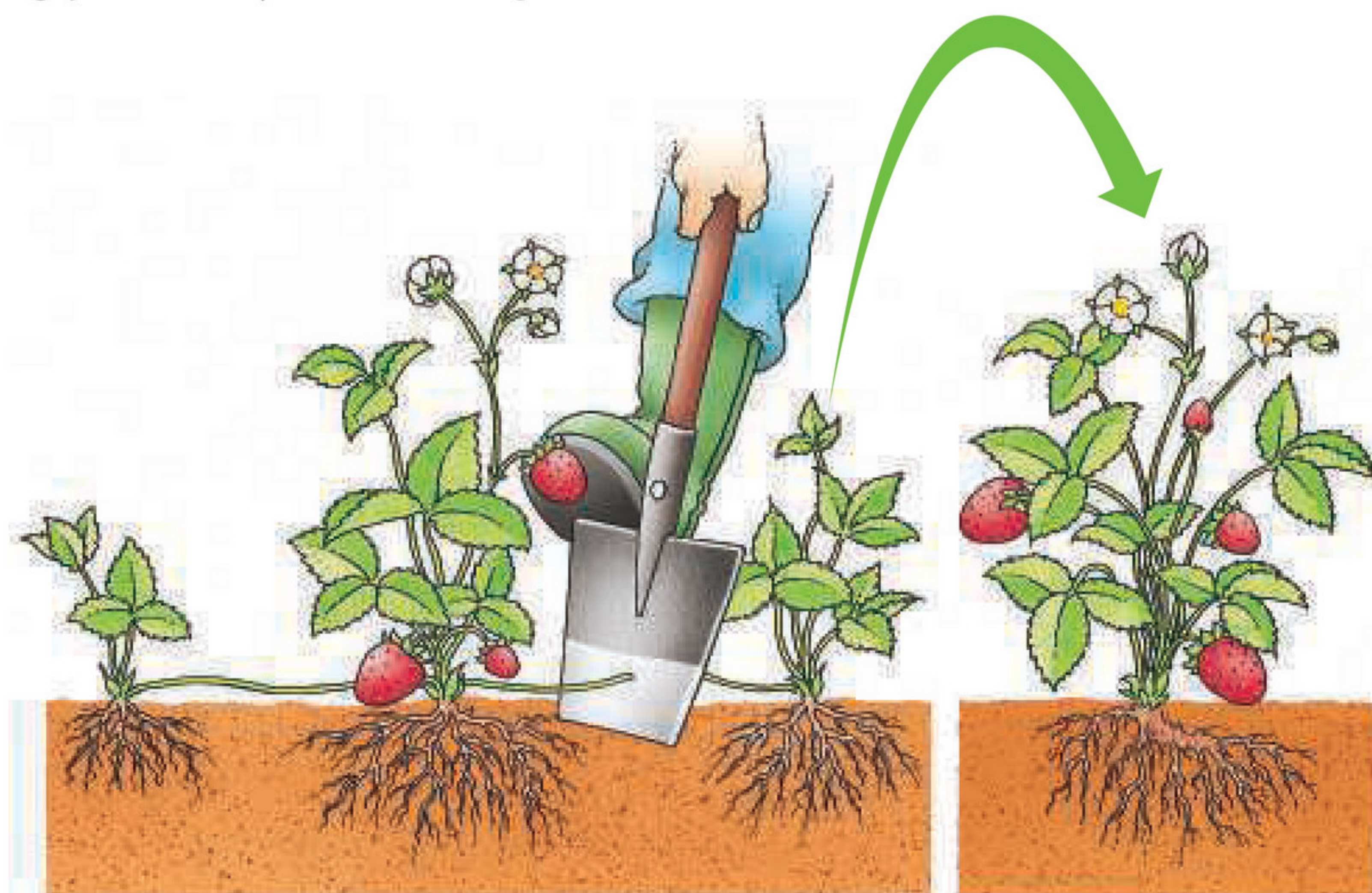
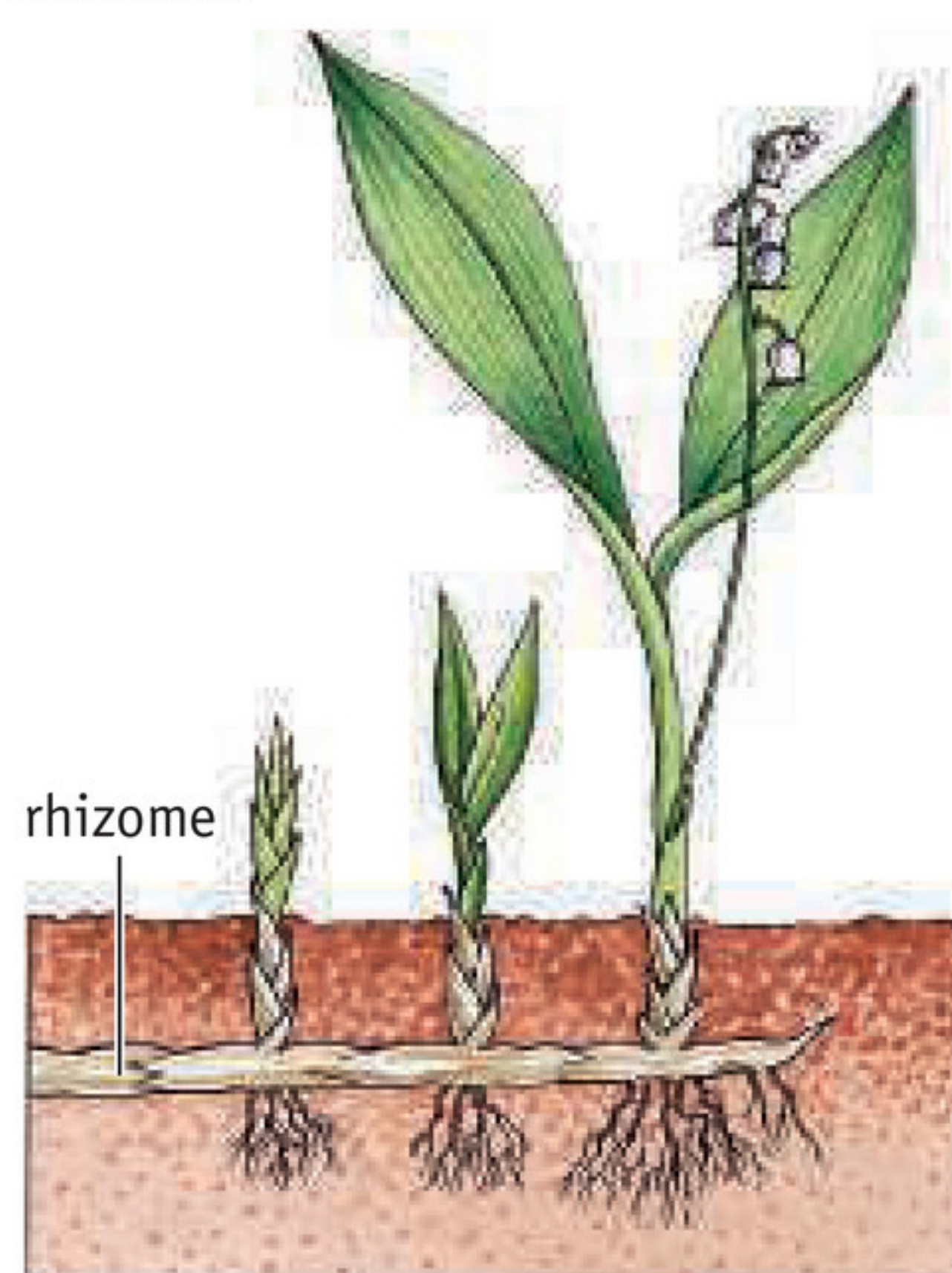


fig. 8 Asexual reproduction through rhizomes.

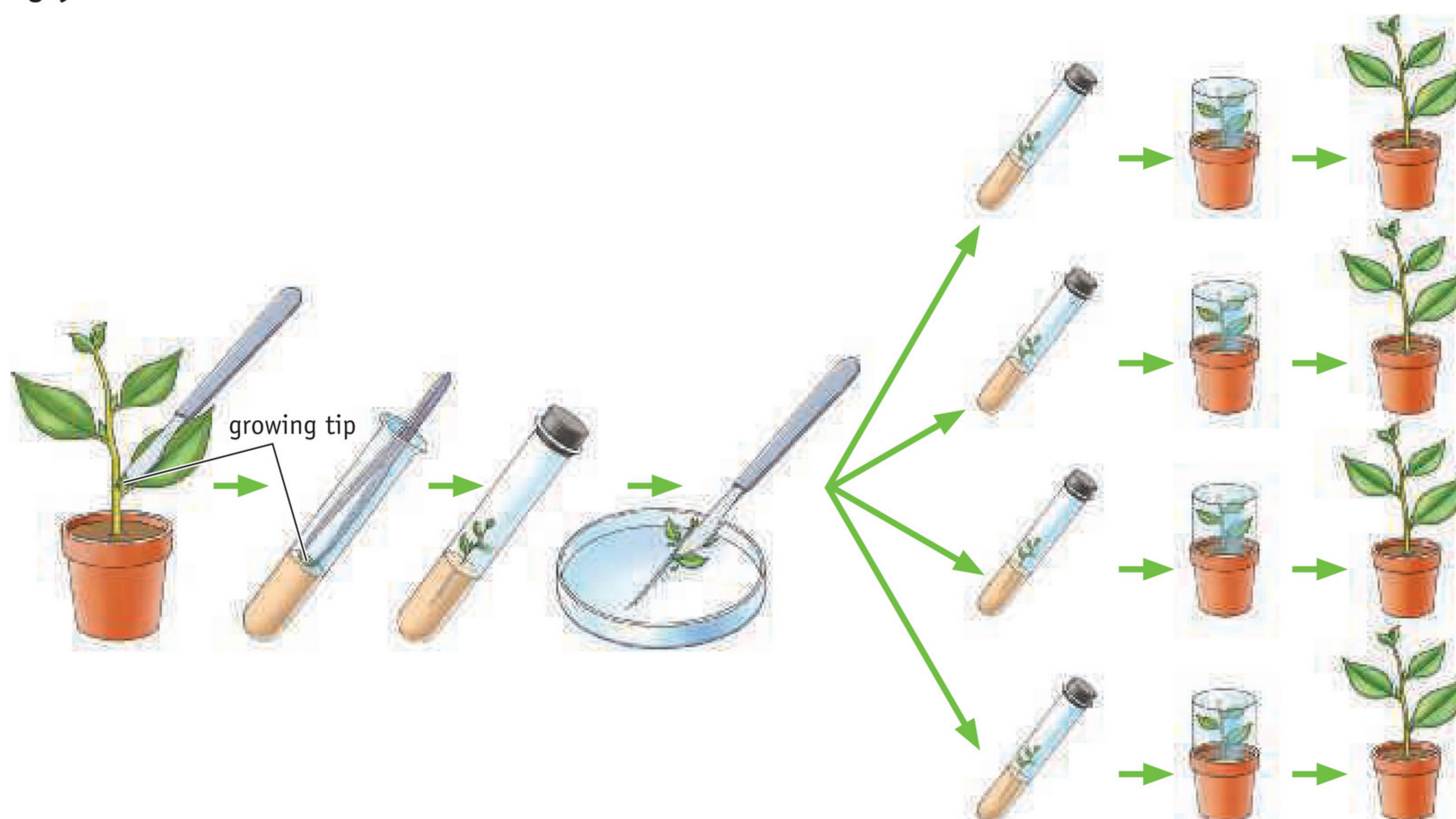


TISSUE CULTIVATION

Plant growers use asexual reproduction a lot. They call it plant **propagation**. One simple method of propagation is taking cuttings. A piece of stem is put in a jar of water. The stem will develop roots. When the roots are big enough, the stem is put into the soil, where it can grow into a new plant.

Another method of plant propagation is **tissue cultivation** (see figure 9). The plant cultivator cuts off small nodules from a plant. A cut-off nodule like this is called a **growing tip**. The grower puts the growing tips into test tubes containing a special nutrient. The tips develop into small plants. After about six weeks, new growing tips will appear on each of the new plants. These can once again be put in test tubes containing the nutrient medium, producing even more new plants. Within a year, this method lets the cultivator grow more than fifty thousand new plants that all have the same hereditary characteristics.

fig. 9 Tissue cultures.

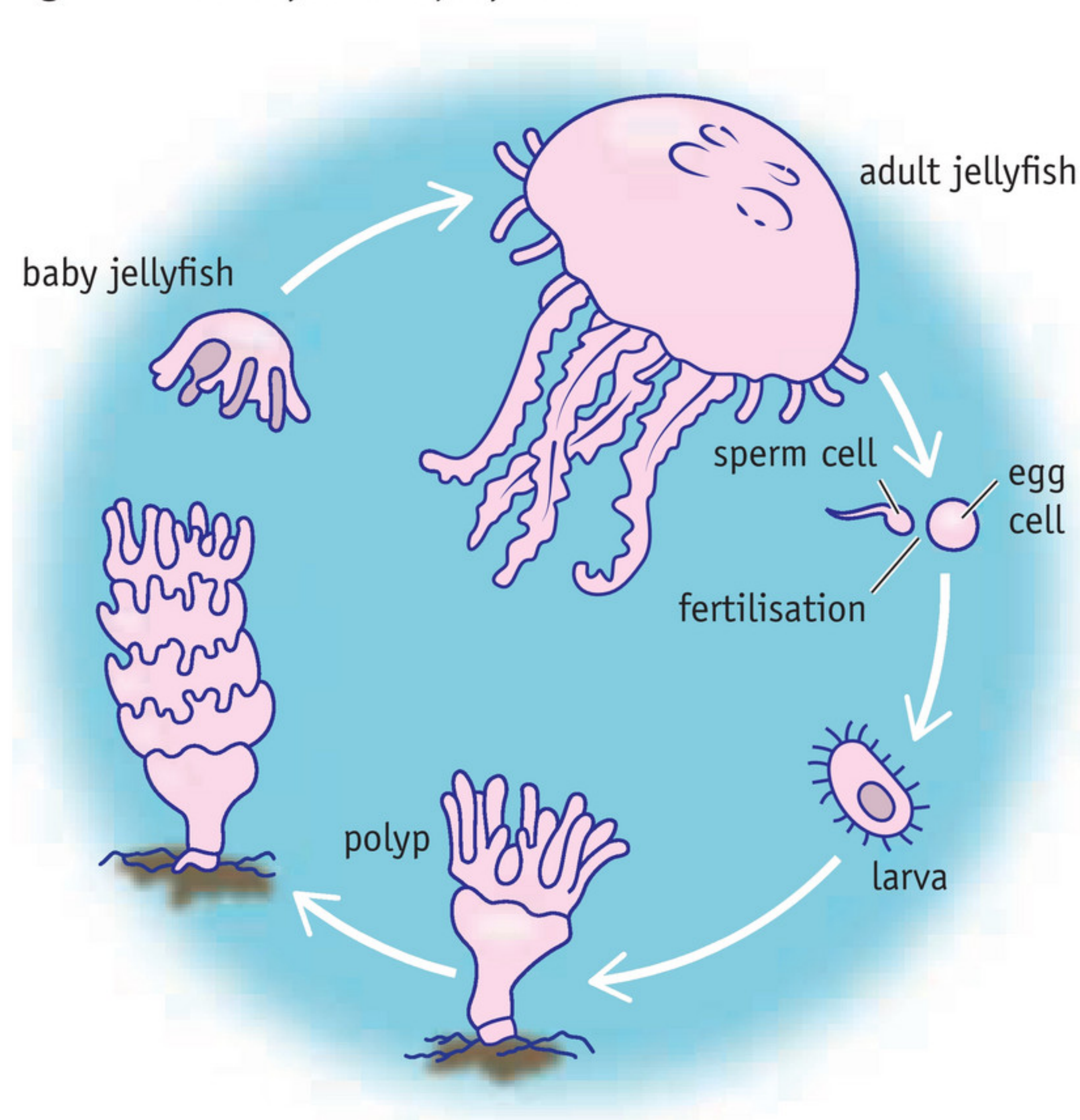


OTHER ORGANISMS

It's not only plants that can reproduce asexually. Single-celled organisms such as bacteria reproduce by cell division. No fertilization takes place during cell division and so the offspring have exactly the same DNA as the parent. Yeasts (single-celled fungi) reproduce by budding.

Almost all animals can only have offspring by sexual reproduction. Nevertheless, there are a few animals that can reproduce asexually too. A jellyfish starts its life as a polyp (see figure 10). A polyp is attached to the seabed, with its mouth and tentacles upwards. Small jellyfish that are attached to one another grow in the polyp by asexual reproduction. Eventually the baby jellyfish separate and grow into adult jellyfish, which live in the water with their mouths and tentacles downwards. New polyps are created from the reproductive cells of two jellyfish by sexual reproduction.

fig. 10 The lifecycle of a jellyfish.



KNOWLEDGE

1

a Give six methods of asexual reproduction in plants.

b Choose the correct description for each word.

- | | | |
|--------------------|-----------------------|--|
| A bulb | ☐ | ☐ 1 a cut-off nodule of a plant is placed on a nutrient medium |
| B cell division | ☐ | ☐ 2 stalks above ground |
| C tuber | ☐ | ☐ 3 stalks below ground |
| D runner | ☐ | ☐ 4 a new cell grows from a parent cell |
| E tissue culturing | ☐ | ☐ 5 thickened leaves |
| F roots | ☐ | ☐ 6 thickened stalk |

c What is the difference between the way a runner and a rhizome grow?

2

Female aphids can reproduce asexually.

a This form of reproduction *does not* / *does* need males.

b The offspring of a female aphid have *the same* / *different* hereditary characteristics.

c A bacterium divides. Its offspring can divide after 30 minutes. The offspring of that offspring can also divide after 30 minutes.

Do all the descendants have the same hereditary characteristics as the original bacterium? Explain your answer.

d One phase in the lifecycle of a jellyfish is the polyp.

Are the hereditary characteristics of a polyp the same as that of the mother jellyfish? Explain your answer.

3

The piggyback plant (*Tolmiea*) is a familiar houseplant. In this houseplant, plantlets develop at the start of the leaf blade (see figure 11). If you put these young plants into the soil, they will develop into new plants.

Are these new plants grown by sexual or asexual reproduction? Explain your answer.

fig. 11 Piggyback plant.



4

**Summary**

Make a summary of this Basics section.

Asexual reproduction:

-
-
-

Examples:

- bacteria:
- fungi:
- animals:
- plants:

INSIGHT

5

A crocus has a type of tuber called a corm, rather than a bulb as most people think.

Figure 12.1 shows you a photo of a crocus corm that has been cut in half.

- a** How can you tell that a crocus has a tuber and not a bulb? Write down a characteristic that you can see in figure 12.1.
- b** Figure 12.2 is a picture of some garlic. Each clove of garlic consists of two food storage leaves and a bud. Figure 12.3 shows a radish. Explain which of the two is a bulb and which is a tuber.

fig. 12 Bulbs and tubers.



1 crocus



2 garlic



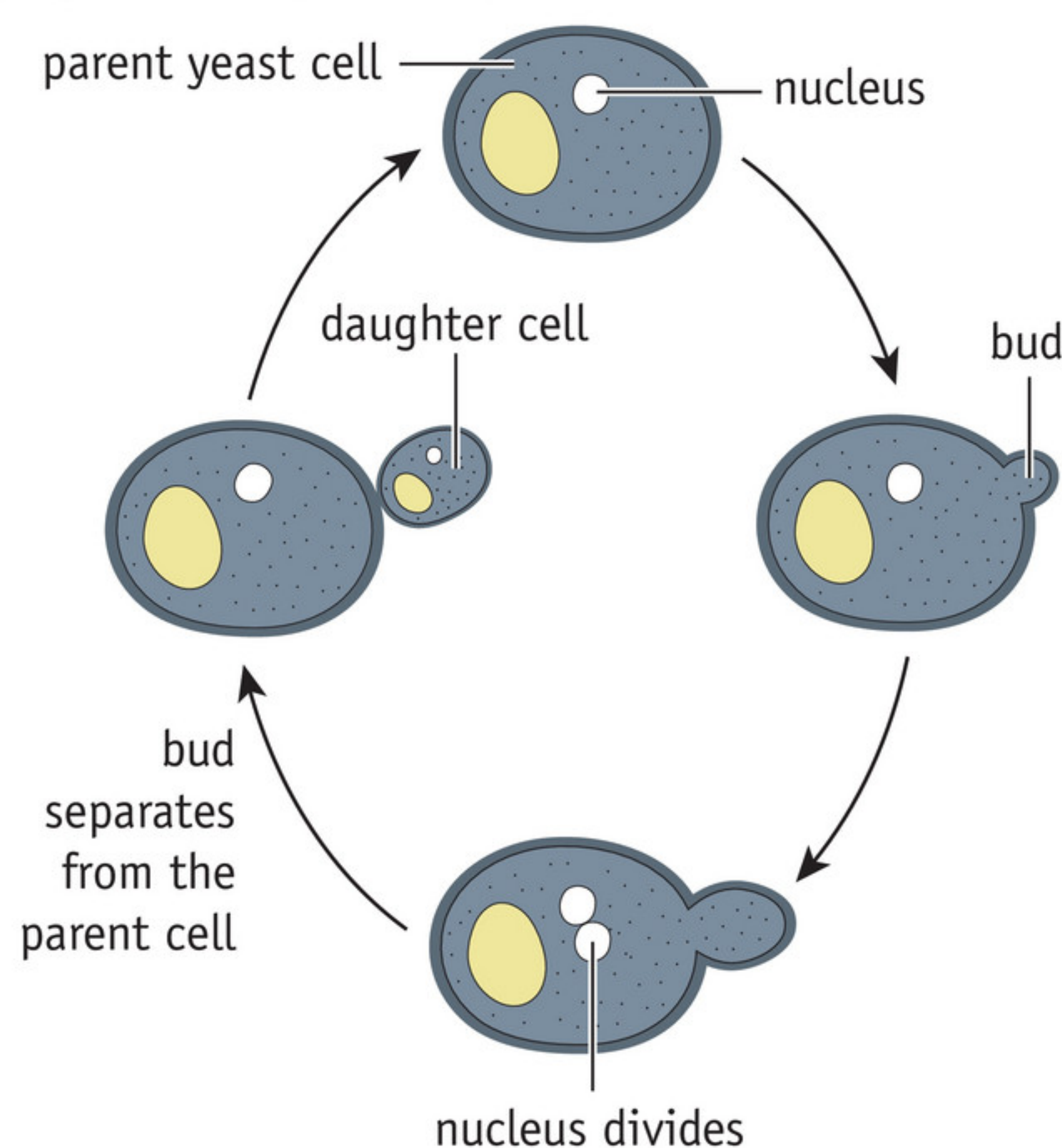
3 radish

6

Figure 13 gives schematic drawings of the reproduction of yeast, a single-celled fungus. This method of reproduction is called budding: when the bud is closed off and separates, a new yeast cell grows.

- a** Does the new yeast cell have different hereditary characteristics to the parent cell? Explain your answer.
- b** A new characteristic appears in a yeast cell: it can divide more rapidly at low temperatures.
Can the offspring of this yeast cell also divide more rapidly? Explain your answer.

fig. 13 The lifecycle of a yeast cell.



7

Why does fruit spoil quickly when it is hot?

8

- a** A farmer has a potato plant with some good characteristics. He wants to grow potatoes with exactly the same characteristics as the potatoes from this plant. Would it be better for him to plant out tubers from the plant or seeds from it? Explain your answer.
- b** A potato breeder collects potatoes of various varieties from several farmers. The breeder selects tubers from the varieties from his collection with the biggest potatoes to grow using asexual reproduction.
Is there any point in that if he is aiming to get large potatoes? Explain your answer.
- c** A Dutch farmer has a collection of potatoes of the 'Bintje' variety. All these potatoes come from the same plant. He selects the biggest potatoes to grow using asexual reproduction.
Is there any point in that if he is aiming to get large potatoes? Explain your answer.

+ 9

Bacteria reproduce asexually by division.
Are there male and female bacteria? Explain your answer.

HOW IT FITS TOGETHER the living world

CORPSE FLOWERS COME TO LIFE

The titan arum is an unusual plant. When it blooms, it can be up to three metres tall. The plant gives off an odour of blue cheese, rotting meat and faeces.

The titan arum is not only known for its titanic size: the shape is unusual too. Its scientific name is *Amorphophallus titanum*, which translates as a ‘giant deformed penis’. It sometimes gets called the ‘penis plant’ in Dutch but, because of its unusual smell, in English it is more often the ‘corpse flower’. When it flowers, hundreds of small florets grow on an upright hollow tube. The tube is part of the plant. All around it is a large leaf. The female flowers grow right at the bottom of the tube. Just above them is a ring of tiny male flowers. So the photograph isn’t showing you a single flower: this is an ‘inflorescence’ containing hundreds of small flowers.

In the wild, the plant flowers once every three years. Cultured plants only flower once every seven to ten years elsewhere; but in the United States, titan arums seem to all flower at once, and more often. Some scientists think this is because they are produced by cuttings. Because they all originate from the same plant, they will all flower at the same time.

fig. 14 The titan arum.



10

Read the text “Corpse flowers come to life”.

- a** Explain why taking cuttings from a titan arum is a form of asexual reproduction.
- b** Do the cuttings have the same hereditary characteristics as the parent plant? Explain your answer.
- c** Can the titan arum also reproduce asexually? Explain your answer.
- d** The smell of the ‘corpse plant’ is not nice and sweet, like the scent of nectar. Not all insects are attracted to it, but some still are.
Explain why a plant with such a nasty smell still attracts insects.

 Go to the *Flash cards* and the *Test yourself* section.

6 Sexual reproduction

LEARNING OBJECTIVES

- 6.6.10 You can explain that each of the parents provides 50% of the DNA in sexual reproduction.
 6.6.11 You can give examples of sexual reproduction.

TAXONOMY	LEARNING OBJECTIVES AND EXERCISES		
	6.6.10	6.6.11	6.5.8*
Remembering			
Understanding	1, 2, 3	3	
Using	5, 7, 8ab, 10abc	6	8ab
Analysing	9, 10de	4	

*You can find this learning objective in another Basics section.

Fertilization happens when the nucleus of a pollen grain fuses with the nucleus of the ovum in the ovule. Two sex cells merge to produce a fertilized plant embryo.

SEX CELLS

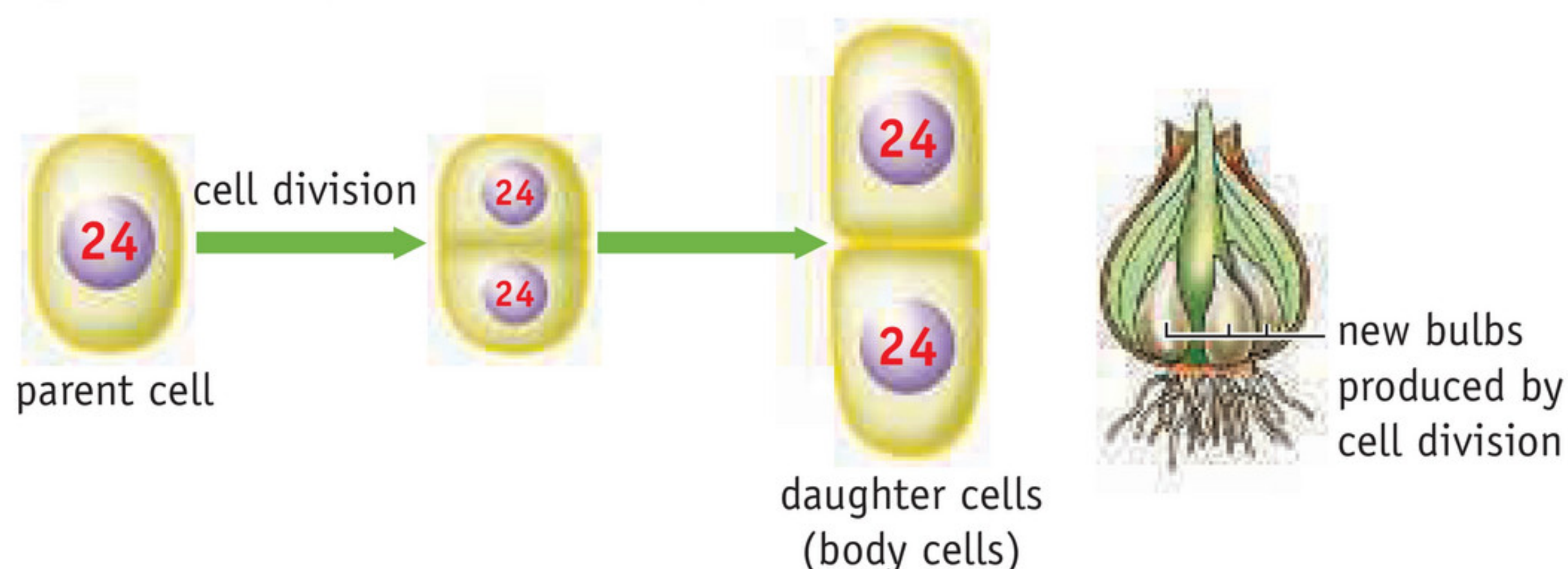
When fertilization is involved in reproduction, we call it sexual reproduction. In seed plants, sexual reproduction takes place when the nucleus of a pollen grain (the male sex cell) fuses with the nucleus of an egg cell (the female sex cell). A new organism can grow from a fertilized ovum.

Sexual reproduction always involves two **sex cells** or gametes. In seed plants, those sex cells can come from the same plant. That happens in self-pollination, for instance. The sex cells can also come from two different plants (of the same species). That happens in cross-pollination.

HOW SEX CELLS ARE PRODUCED

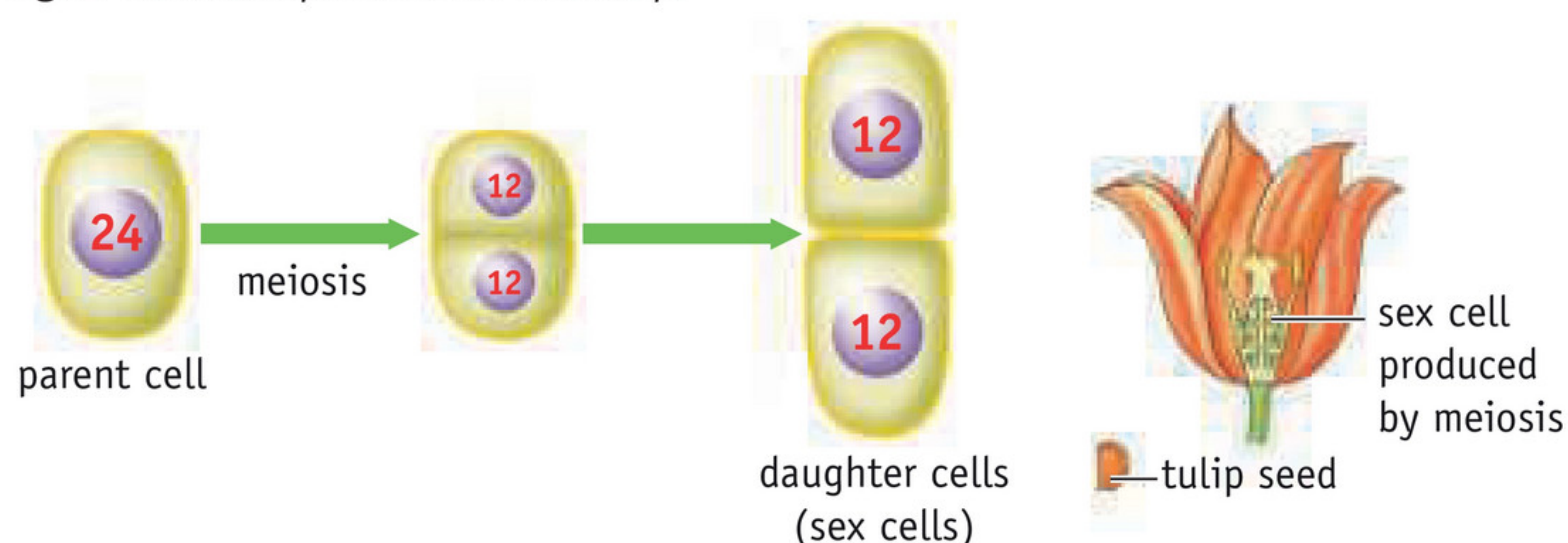
In tulips, asexual reproduction occurs through the bulbs. All the cells in a bulb were produced by cell division. The parent cell of a tulip has 24 chromosomes (see figure 1). Every time a cell divides, the chromosomes are first copied and then split between the daughter cells (body cells). After asexual reproduction, the cells of the offspring all have the same number of chromosomes and the same DNA as the parent plant.

fig 1 Asexual reproduction in a tulip.



Tulips can also reproduce sexually using seeds. Sex cells are produced for sexual reproduction. This is done through a special form of cell division called **meiosis**. In meiosis, the chromosomes are not copied but are instead divided between the daughter cells (sex cells or 'gametes'). Sex cells therefore only have half as the number of chromosomes of the parent cells (see figure 2).

fig. 2 Sexual reproduction in a tulip.



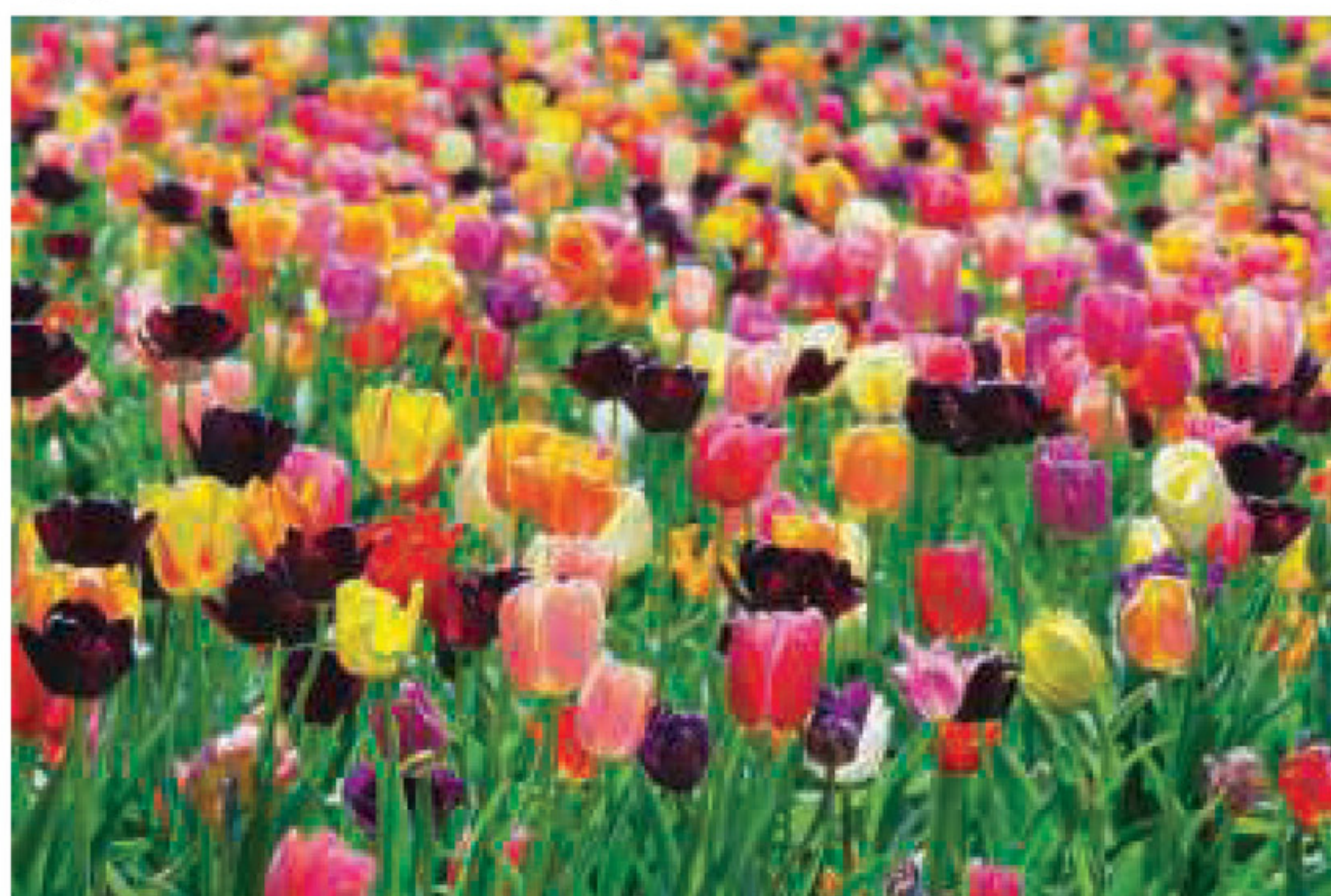
FERTILIZATION

When a pollen grain of a tulip (with 12 chromosomes) fuses with an ovum of a tulip (which also has 12 chromosomes), a fertilized ovum with 24 chromosomes is created. Ordinary cell division produces a plant embryo from the fertilized ovum (with 24 chromosomes in every cell). A seedling can grow from the plant embryo. The new tulip plant has 24 chromosomes in each cell.

There are small differences between two organisms of the same species (variation). There are also small differences in the DNA of two organisms (see figure 3). Cross-pollination means that the DNA of two different plants (with small differences in their DNA) is merged. Each of the parents provides 50% of the DNA. The DNA of the offspring is therefore not exactly the same in sexual reproduction.

In sexual reproduction, the offspring do not have exactly the same hereditary characteristics as the parents.

fig. 3 Sexual and asexual reproduction.



1 sexual reproduction by seeds: the DNA is not exactly the same

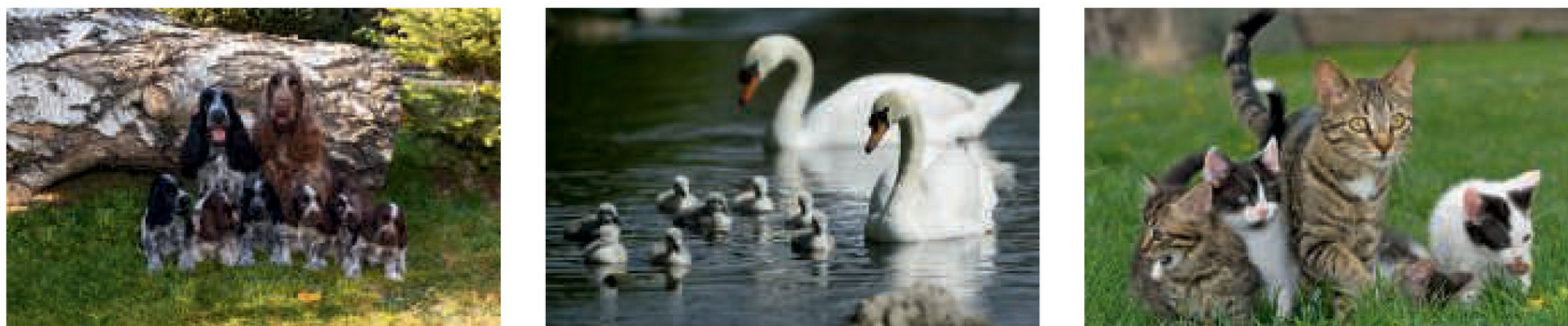


2 asexual reproduction by bulbs: the DNA of all these tulips is exactly the same

ANIMALS

Animals reproduce sexually. In animals too, the nuclei of a male sex cell and a female sex cell fuse together during fertilization. The sex cells are produced by meiosis. The offspring therefore do not have exactly the same hereditary characteristics as the parents (see figure 4).

fig. 4 Sexual reproduction in animals.

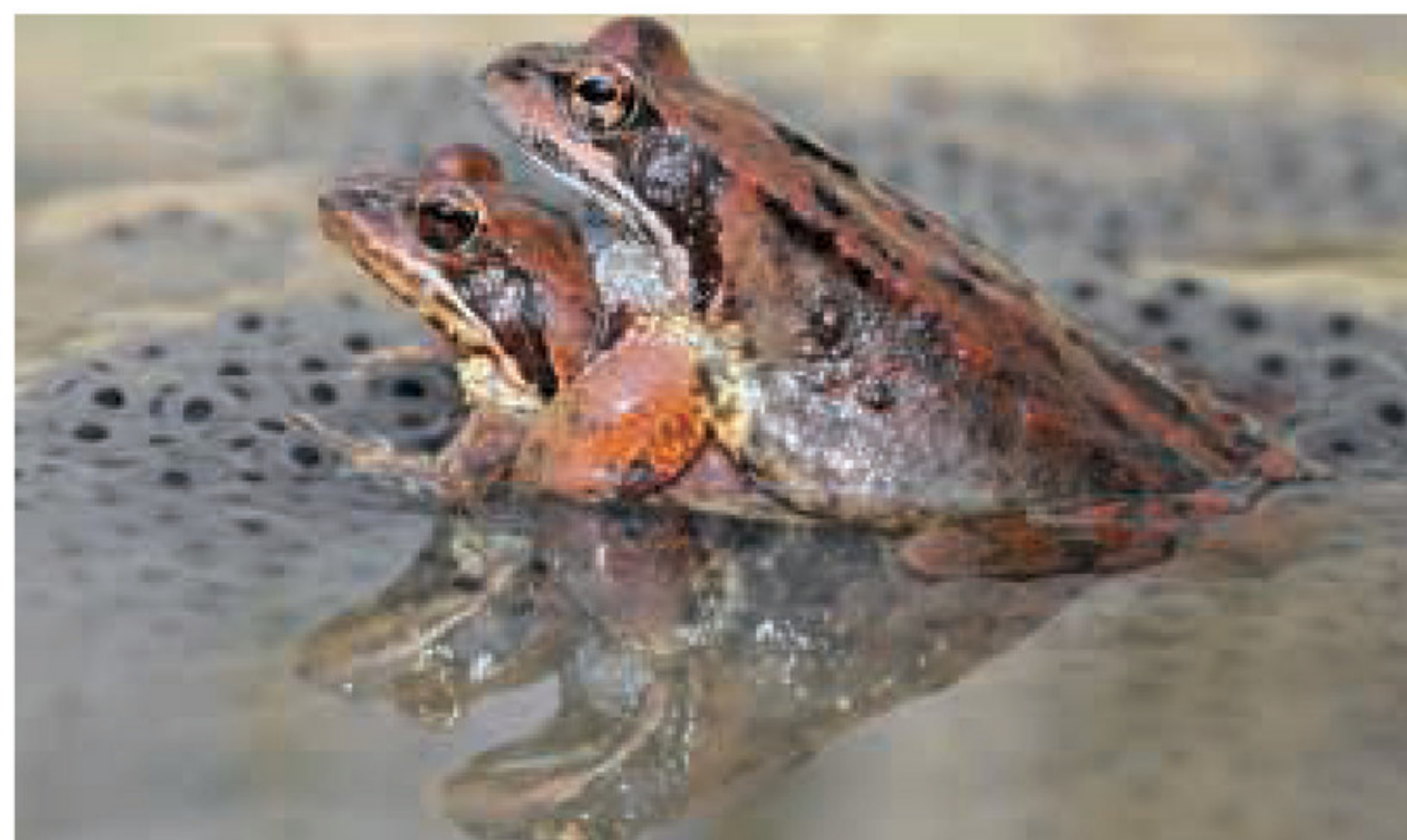


In birds, the young (chicks) hatch from eggs. Other animals lay eggs too, such as frogs, fishes and insects. Animals that lay their eggs on land produce a shell around the eggs. The shell protects the eggs from drying out. Animals that lay their eggs in water do not need an eggshell. Among animals that live in water, **external fertilization** also occurs. Both the egg cells and the sperm cells are then deposited in the water (see figure 5). Fertilization then takes place in the water. This is the case for fishes, for example. The female fish lays the eggs. The male fertilizes the eggs, for example by swimming above them while depositing sperm cells.

fig. 5 Fishes lay eggs and fertilize them in the water.



fig. 6 Mating frogs.



In frogs, the male gets on top of the female during mating (see figure 6). The male produces sperm cells at the same moment as the female deposits the eggs. Fertilization takes place in the water (external fertilization). The male may stay mounted on the female for several days.

Insects mostly use **internal fertilization**. This means that fertilization takes place inside the body of the female. After fertilization, the female insect lays eggs that larvae develop inside. In dragonflies, the male has an organ for gripping at the end of the abdomen that is used for taking hold of the female by the neck during mating (see figure 7). Birds and mammals also use internal fertilization.

fig. 7 Mating dragonflies.



KNOWLEDGE

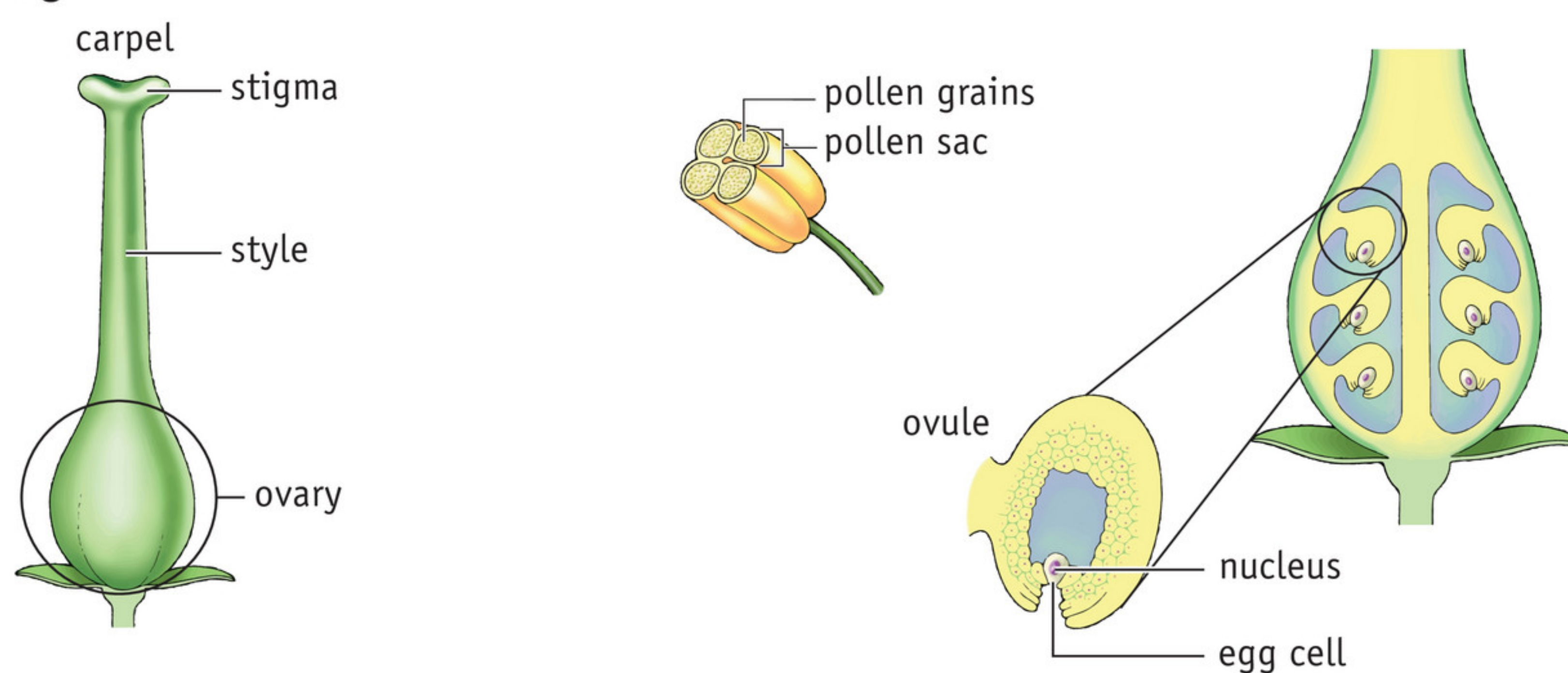
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Figure 8 shows you the parts of a flower.

- a** For each part, write down whether its cells will have half the normal number of chromosomes (*half*) or the normal number (*normal*).
- b** Is self-pollination a form of sexual or asexual reproduction? Explain your answer.

fig. 8



2

Figure 9 shows you a couple and their two children.

Explain why the children have lighter skin than their mother but darker skin than their father.

fig. 9



3



Summary

Make a summary of this Basics section. Do that by answering the questions.

- What are the features of sexual reproduction?
- How are gametes (sex cells) produced?
- What are the sex cells called in plants and in animals?
- What happens to the hereditary information during fertilization?
- What two forms of fertilization are there in animals?

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INSIGHT

4

External fertilization is only possible in animals that live in water. Explain why.

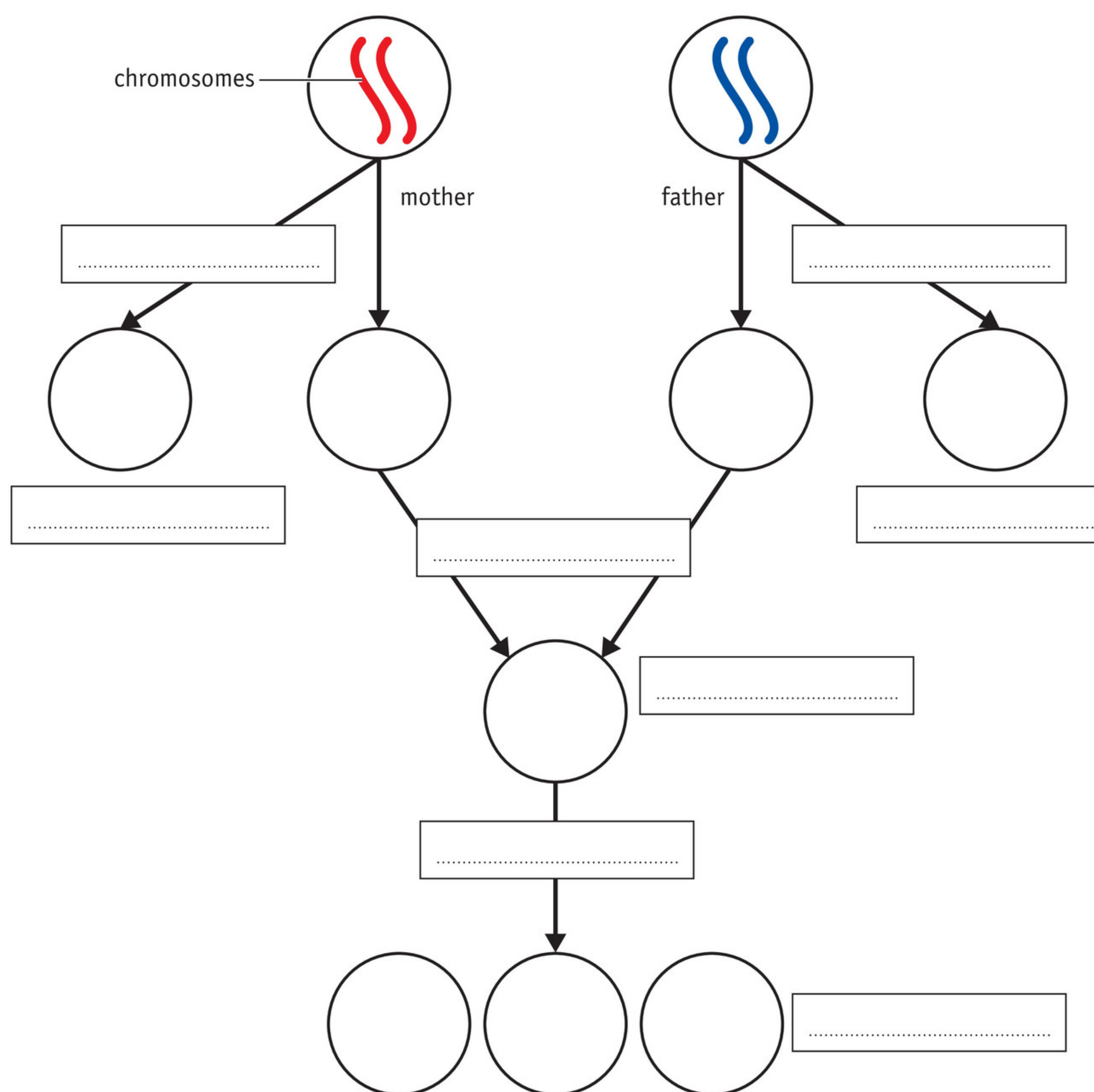
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Figure 10 is a diagram showing meiosis and fertilization. Each circle represents a cell nucleus. In this organism, the nuclei of its body cells contain two chromosomes.

- Draw the correct number of chromosomes in the correct colours in each of the empty nuclei.
- Complete the diagram. Use the terms *fertilized egg cell – fertilization – cell division – sex cell – body cell – meiosis*. Some words may have to be used more than once.

fig. 10



6

Choose the right form of fertilization for each group of animals. There is one group where this can occur in two ways.

- 1 amphibians: *internal / external*
- 2 reptiles: *internal / external*
- 3 fish: *internal / external*
- 4 birds: *internal / external*
- 5 mammals: *internal / external*

7

The egg cells of a melon plant (*Cucumis melo*) have twelve chromosomes.

- a** How many chromosomes do the cells in its leaves contain?
- ☐ A 6
 - ☐ B 12
 - ☐ C 24
 - ☐ D 48
- b** How many chromosomes would one of its pollen grains contain?
- ☐ A 6
 - ☐ B 12
 - ☐ C 24
 - ☐ D 48
- c** How many chromosomes are there in a carpel?
- ☐ A 6
 - ☐ B 12
 - ☐ C 24
 - ☐ D 48
- d** Melons – the fruits of the plant – containing seeds grow on a melon plant.
The hereditary information of the cells in a leaf and in:
- 1 the cells of the seeds is *the same* / *different*.
 - 2 the cells of the fruit pulp is *the same* / *different*.

8

A grower wants to produce a plant with purple flowers. He has plants with red flowers, yellow flowers, blue flower and white flowers.

- a** Explain why the plant breeder must make the plants reproduce sexually if he is to get a plant with purple flowers.
- b** The grower has finally succeeded in breeding a plant with purple flowers. He wants to sell a hundred thousand of them.
Explain why the grower must make the purple-flowered plants reproduce asexually.

+ 9

Bdelloidea are microscopic small animals that can be found primarily in fresh water and wet soil (see figure 11). The females reproduce by laying unfertilized eggs that young animals grow from.

- a** Explain why there are no male Bdelloidea.
- b** There is no fertilization in Bdelloidea. Even so, not all Bdelloidea have exactly the same hereditary information in their cells. This is because they very occasionally pick up other hereditary information. Not from their own species, but from other organisms such as bacteria, fungi and plants.
What similarity does this ‘method’ have with fertilization?
- c** Give an argument that states why this ‘method’ is not fertilization.

fig. 11 Bdelloidea.



HOW IT FITS TOGETHER the living world

BEES

A bee lives in a colony with as many as sixty thousand other bees. At the head of this colony is a single queen. There are also a few hundred drones (male bees) and the rest of this ‘bee state’ consists of workers. The queen, drones and workers are produced in different ways. The queen lays both fertilized and unfertilized eggs. The unfertilized eggs produce the drones. The fertilized eggs produce the workers. The queen herself also came from a fertilized egg. Because she was given a special kind of food (called ‘royal jelly’) as a larva, she developed into a queen. The worker bees are infertile; only the queen can lay eggs. Several drones fertilize the queen. She then lays both fertilized and unfertilized eggs.

fig. 12 Worker bees with the queen in the middle.

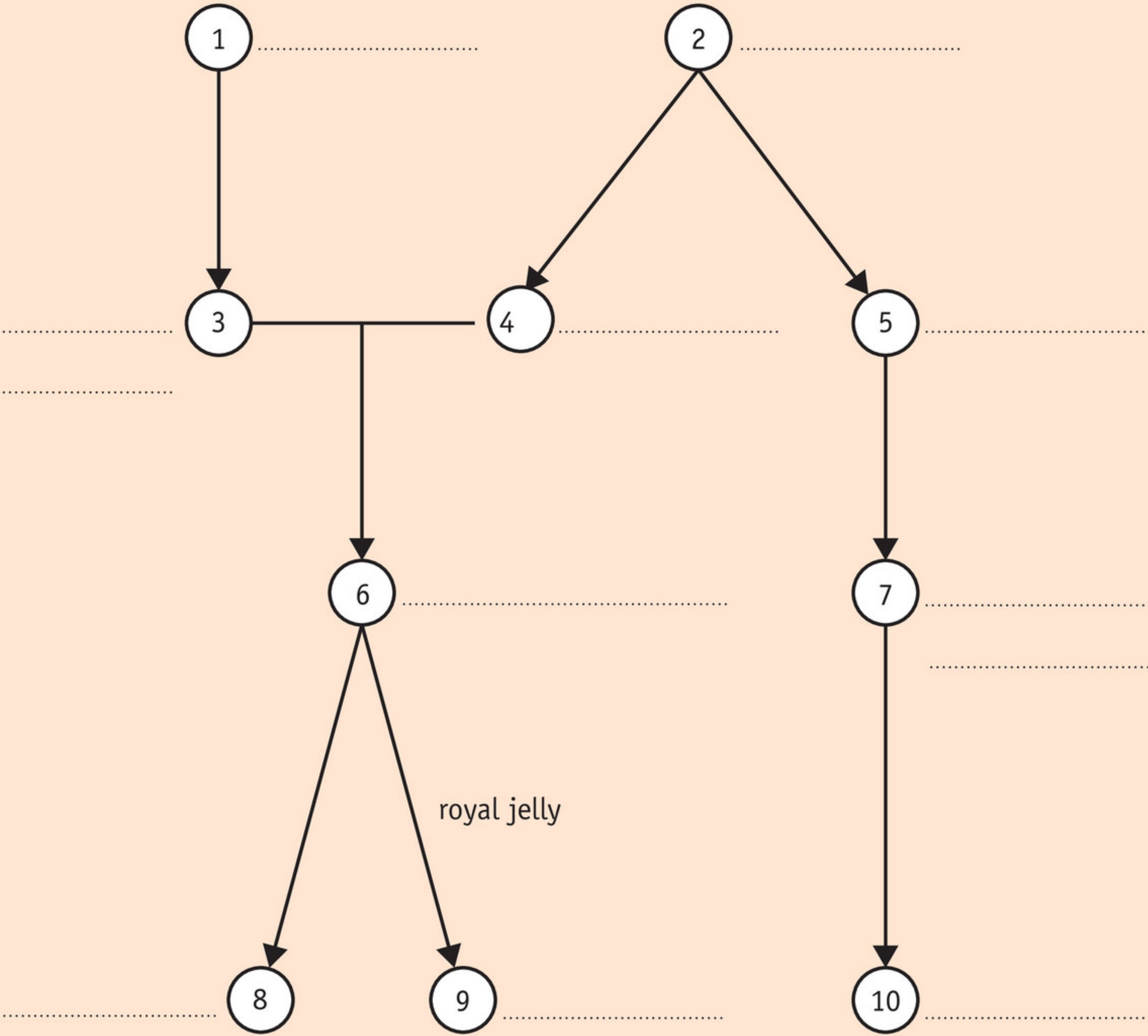


10

Read the text about “Bees”.

- a Complete the table for figure 13. Choose between: *fertilized egg cell – drone – egg cell – queen – unfertilized egg cell – worker*. Some words may have to be used more than once.
- b Which descendants of a queen bee (♀) and a drone (♂) have DNA from the father?
 - ☐ A the drones
 - ☐ B the queens
 - ☐ C the workers
- c Can worker bees have offspring? Explain your answer.
- d Which type of bee does not have a father but does have a grandfather?
 - ☐ A a drone
 - ☐ B a queen
 - ☐ C a worker
- e
 - 1 Bees reproduce by internal fertilization. true / false
 - 2 A drone and a worker can have offspring together true / false
 - 3 A drone’s mother is always a worker. true / false
 - 4 A drone has the same number of chromosomes in its body cells as there are in a gamete (sex cell). true / false
 - 5 A worker’s father is always a drone. true / false
 - 6 A worker has twice as many chromosomes as a drone. true / false

fig. 13 Reproduction in bees.



 Go to the *Flash cards* and the *Test yourself* section.

How it fits together

OF FLOWERS AND SHRIMPS

In the seas around Mexico, there are huge fields of seagrasses. These plants absorb more than 25 million tons of carbon dioxide every year. Scientists have discovered a very unusual feature of one species of seagrass, known as turtle grass.

Turtle grass grows on the sea floor. The grass is eaten by turtles (no surprise there!) and also by parrotfish, doctor fish and sea urchins. The leaves grow rapidly, particularly in the spring and summer. During the same period, the plant's stalks grow outwards under the seabed. These stalks then produce new turtle grass plants (see figure 1).

FLOWERS M/F

The part of the plant above the seabed changes in various ways in the spring too. Male turtle grass plants produce three to five white or purple flowers with nine stamens in each. Female plants produce a single white flower. That flower has a lot of carpels: seven of them. Each carpel is forked, so it has two stigmas. The flowers have three small sepals and no petals.

When the male flowers are ripe, they burst open in the middle of the night. They then disperse clouds of sticky pollen grains on the water – around 160,000 grains from each flower! The female flowers open up the next morning, ready to receive the pollen. The flowers remain open for three days.

fig. 1 A turtle and turtle grass.



MARINE ANIMALS

A Dutch-Mexican scientist called Brigitta van Tussenbroek discovered that more than that happens, deep in the night. She filmed flowering turtle grass at night. On the pictures, she saw that hordes of small marine creatures descended upon the sugar-rich pollen grains. Lots of shrimps, bristle worms and amphipods came to eat the pollen when the flowers bloomed and a lot of grains stuck to their bodies. Swimming against the current, they then often rested for a moment on the female flowers. So these 'marine bees' were carrying pollen to the female flowers.

After fertilization, the seeds develop inside a fruit. About eight weeks later, the chestnut-like fruit bursts open. The seeds – up to six of them per fruit – float along on the water to a spot where they can germinate. Blue swimmer crabs and spider crabs are lurking in wait as they go, ready to eat both the seeds and the seedlings. Every embryonic plant that escapes their attention makes the underwater turtle grass field one grass plant richer.

EXERCISES

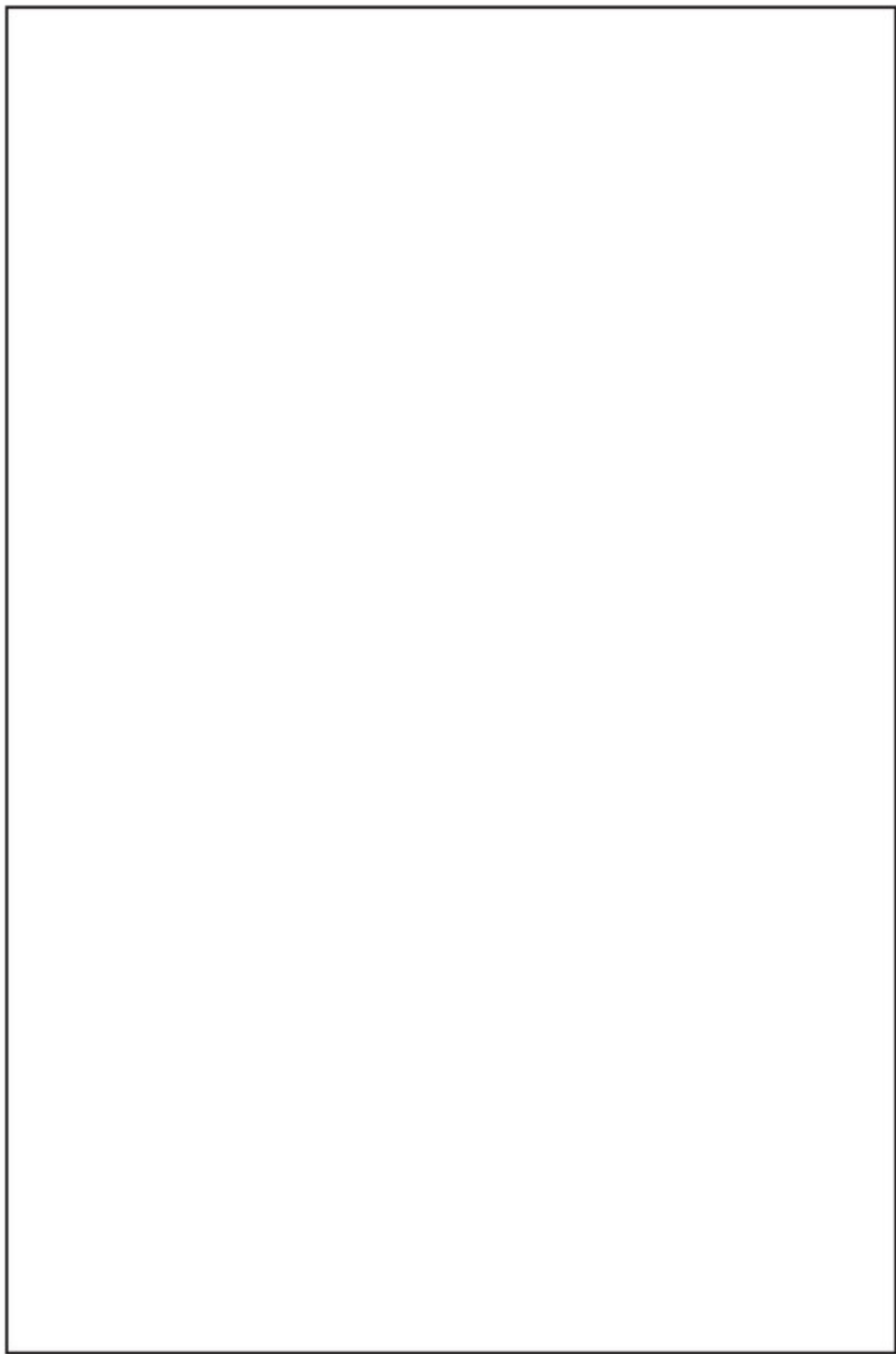
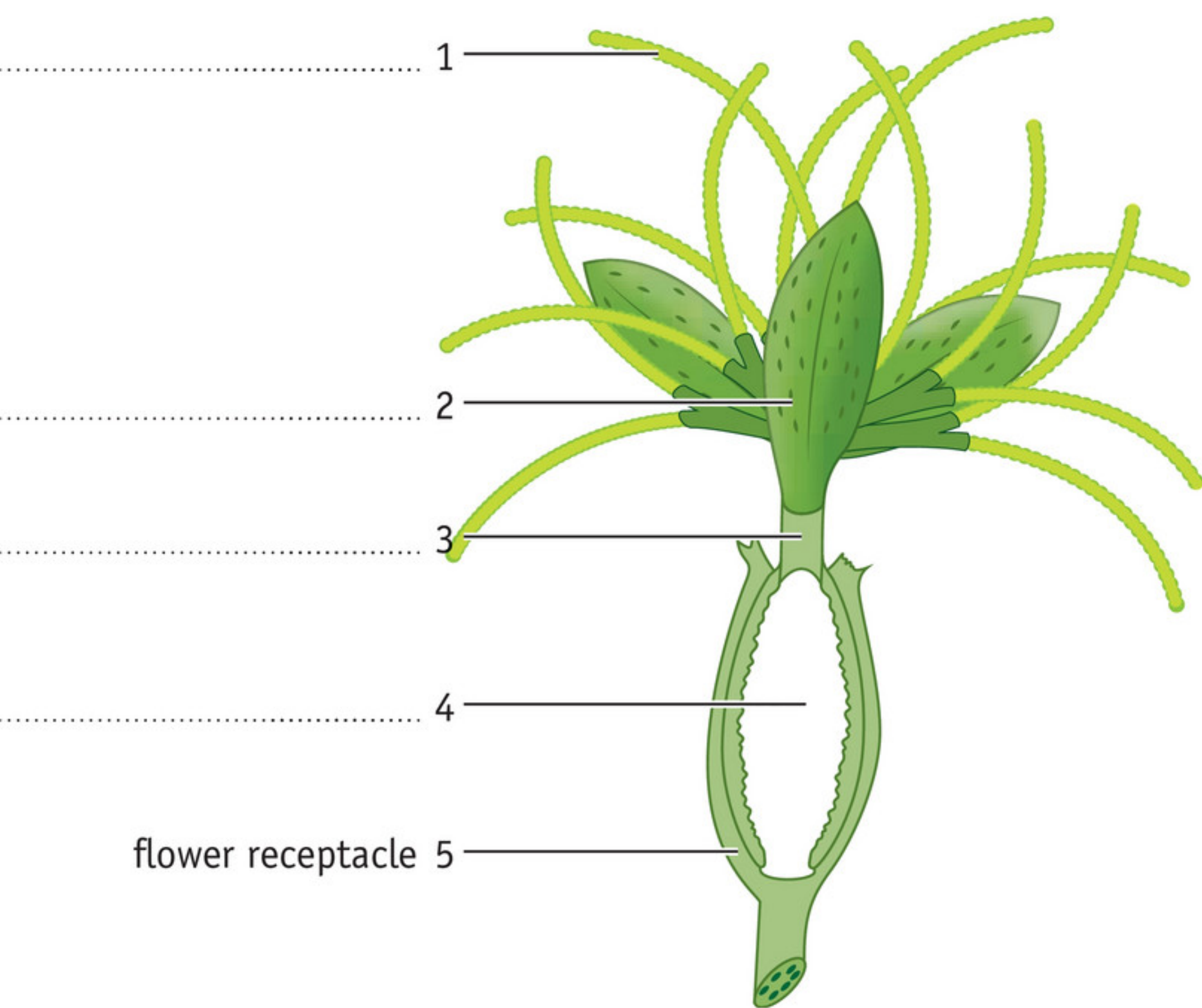
1

Figure 2 shows you a female flower of a turtle grass plant.

- a The *sepals* / *petals* of this flower are *separate* / *fused*.
- b Write down the names of the numbered parts.
- c Draw the ovules in the flower.
- d Draw a male turtle grass flower next to the female flower. Every anther has four pollen sacs.



fig. 2 Turtle grass flower.



2

- a What are the two ways that the male flowers attract the sea creatures?
- b Is self-pollination possible in turtle grass? Explain your answer.
- c Turtle grass has both similarities and differences with respect to insect-pollinated flowers and wind-pollinated flowers.
Complete the table. Write down at least one similarity or difference in each square.
- d The shrimps visit the male turtle grass flowers more often than the female flowers. Explain why.

	Turtle grass flowers	
	similarity	difference
Insect-pollinated flowers		
Wind-pollinated flowers		

3

One of the steps in Brigitta van Tussenbroek’s research involved adding a dye called aniline to the carpels. This dye makes it possible to see pollen tubes in a carpel under the microscope.

- a** If you can see a pollen tube:
- 1 you *know* / *don’t know* for certain that pollination has taken place;
 - 2 you *know* / *don’t know* for certain that fertilization has taken place.
- b** Here are three different parts of a turtle grass plant and three diameters. Which diameter belongs with which part?
- A pollen grain

☐

☐

1 12 mm
- B fruit

☐

☐

2 25 mm
- C seed

☐

☐

3 56 μm
- c** A mature turtle grass plant has 18 chromosomes in every nucleus. How many chromosomes are there in the following parts of the plant:
- 1 pollen grain

9 / 18 / 36
- 2 fruit

9 / 18 / 36
- 3 seed

9 / 18 / 36
- d** Blue swimmer crabs sometimes only eat half of a turtle grass seed. Do you think that the plant embryo in a half-eaten seed is still able to germinate? Explain your answer.

4

- a What form of asexual reproduction occurs in turtle grass?
bulb / tuber / runners / rhizomes
- b Suppose that a fruit of a turtle grass plant contains five seeds.
Do all five seeds contain chromosomes from the same mother plant? Explain your answer.
- c Could all five seeds have chromosomes from the same father plant? Explain your answer.
- d Could a field of turtle grass contain several different plants with the same hereditary characteristics? Explain your answer.

fig. 3



7

Dispersal of seeds

LEARNING OBJECTIVE

6.7.12 You can see how the fruits and seeds of a plant are dispersed from pictures of the plant (or parts of it).

► Practical activity 9

TAXONOMY	LEARNING OBJECTIVE AND EXERCISES
	6.7.12
Remembering	
Understanding	2a
Using	2bcde
Analysing	1

Fruits containing seeds are produced from flowers. Each seed contains an embryo that can develop into a new plant. Seeds can be dispersed (spread) in various ways.

DISPERSAL BY THE PLANT ITSELF

For the plants, it is helpful for the seeds to be spread over a large area. They do not then all end up in the same place, which allows more of them to germinate. Fruits are one way of ensuring that the seeds are dispersed. This can happen in a variety of ways.

The fruits of some plants scatter the seeds themselves. The fruits of the cranesbill (see figure 1.1) spring open when they are ripe. This is done with enough force to throw the seeds some distance (see figure 1.2).

fig. 1 Cranesbill.



1



2

DISPERSAL BY THE WIND

In nature, many fruits and seeds are small and can be dispersed by the wind. These fruits and seeds often have features that let them float in the air for longer. You have undoubtedly blown a dandelion clock at some point (see figure 2.2). What you are doing then is blowing away the fruits (containing the seeds) of the dandelion. The fruit surrounds the seed. This fruit has stayed very small and it does not contain any pulp. Each fruit has a plume of fluff that lets it float in the air (see figure 2.3). The fruits of the birch, maple and linden have wings (see figure 3).

fig. 2 Dandelion.

1



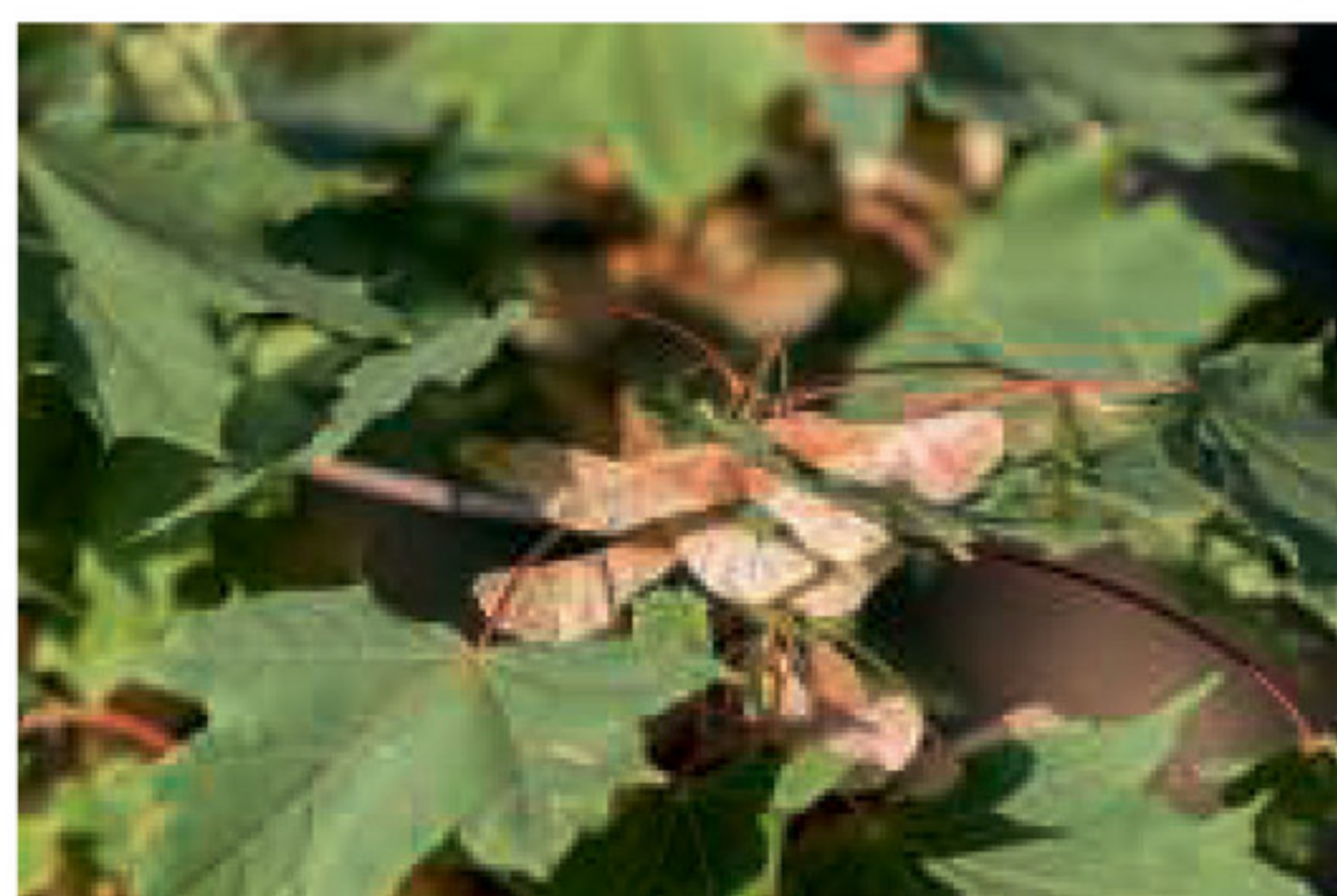
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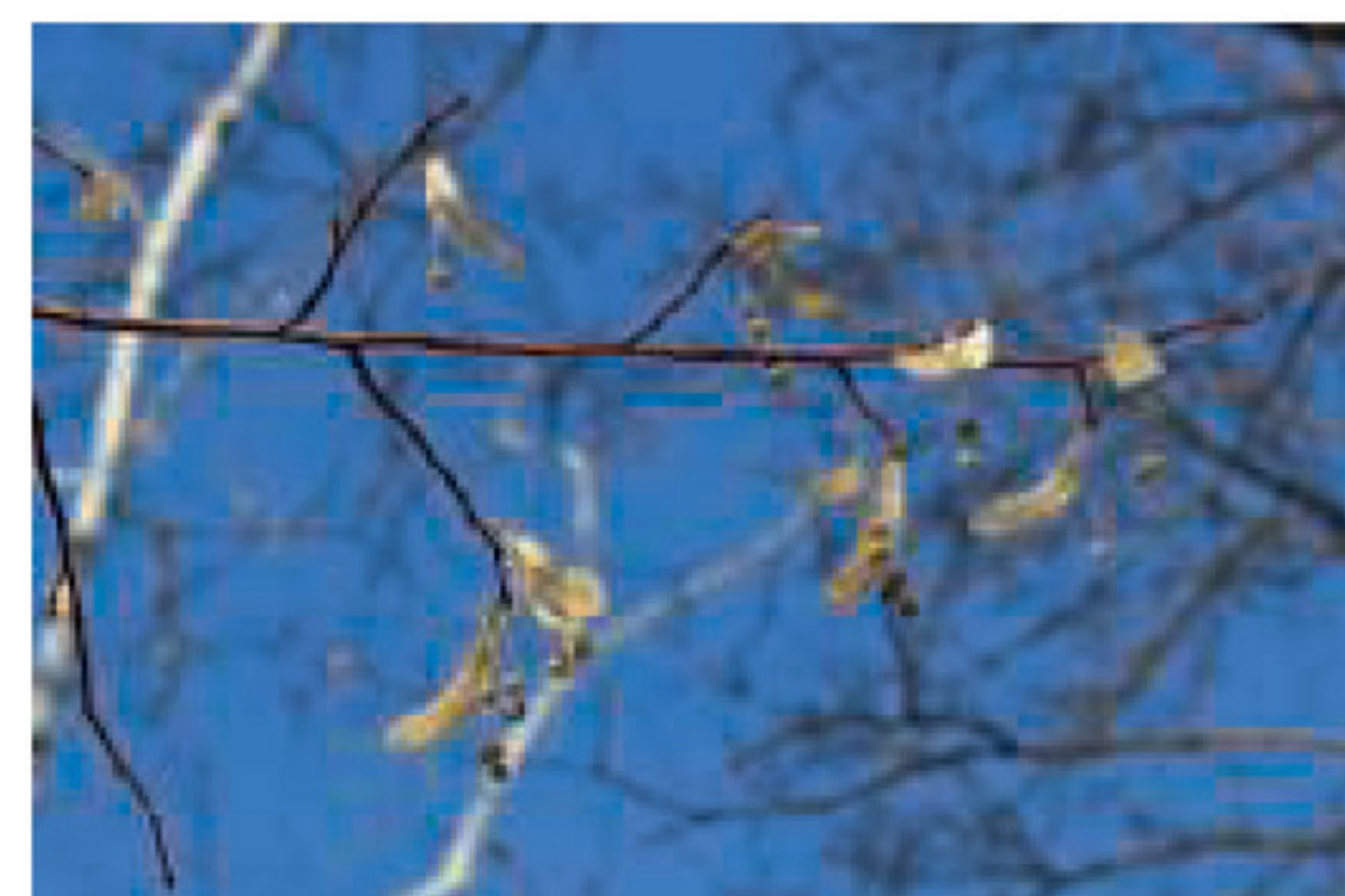
3

fig. 3 Seeds with wings.

1 birch



2 maple tree



3 lime

DISPERSAL BY ANIMALS

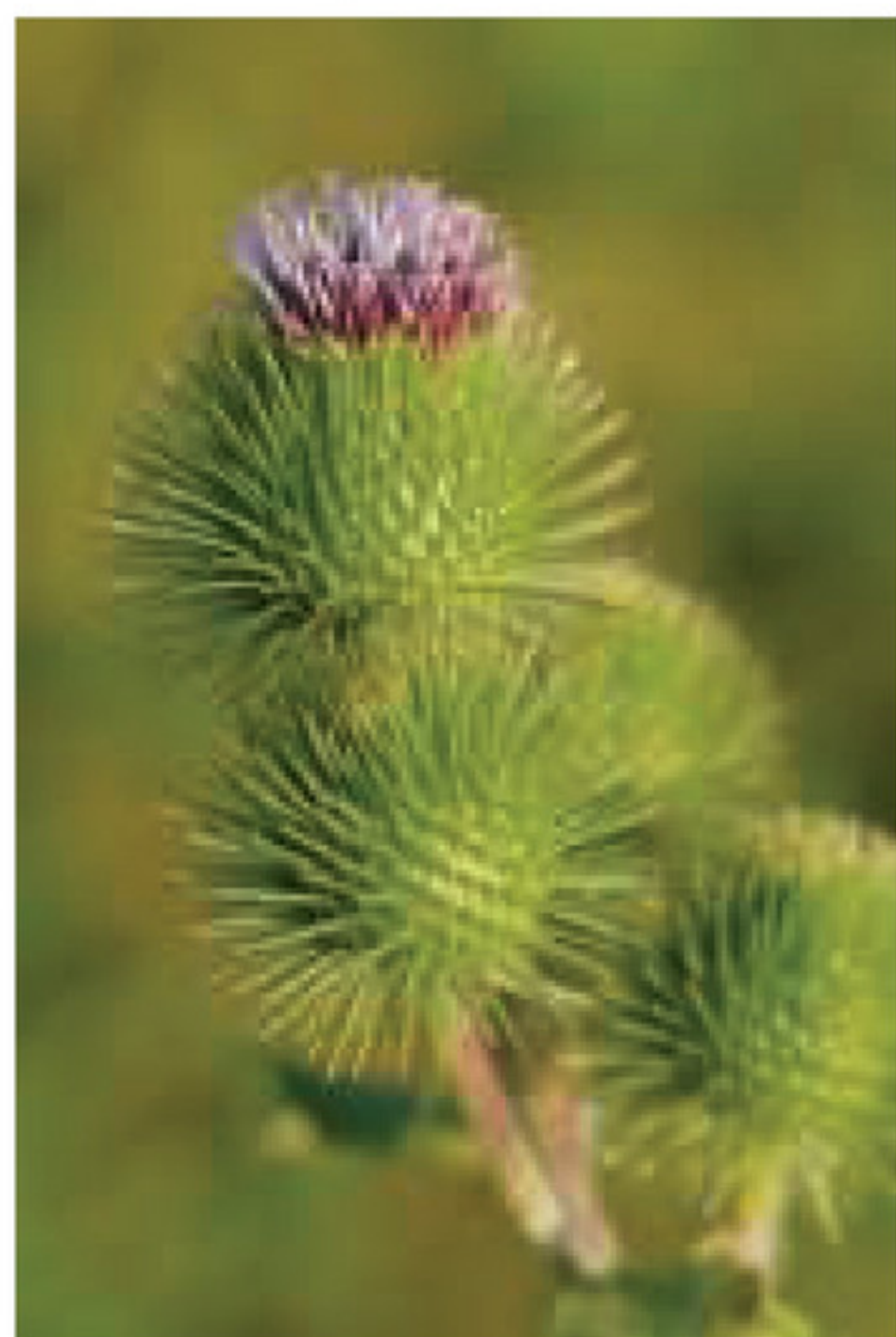
There are also plant species in which animals disperse the fruits and seeds. The fruits in many of these plant species have juicy pulp. Figure 4 shows the fruits (berries) of a rowan tree. Many birds like eating these berries. The fruits enter the birds' stomachs, where the pulp of the fruit is digested but not the seed. The seeds are then passed out in the bird's droppings. If conditions are favourable, the seeds may germinate where they fall.

fig. 4 Rowan.**fig. 5** Jay.

Squirrels gather acorns and beech nuts for their winter food stocks (see figure 5). Not all the seeds are eaten, because an animal may sometimes not use all its stocks of food. The seeds have then been dispersed and may germinate.

Some plant species produce seeds that have small hooks on. These fruits can easily stick onto the fur of passing animals. Later they fall off or are brushed off by the animal. Examples of this are the fruits (burrs) of cleavers and burr marigolds (see figure 6). People disperse seeds as well. This is often done accidentally, for instance when seeds stick in the ribs on the soles of your shoes. The seeds may then fall off again somewhere else.

fig. 6 Dispersal by animals.



1 cleavers (sticky burrs)



2 fruits in the fur

EXERCISES

1

Fruits are often used for making sure that seeds are dispersed, but sometimes it is done by the seeds themselves. With peanuts, for example, it is the seed itself (the peanut) that gets eaten and not the fruit. Explain how the seeds themselves get dispersed.

2

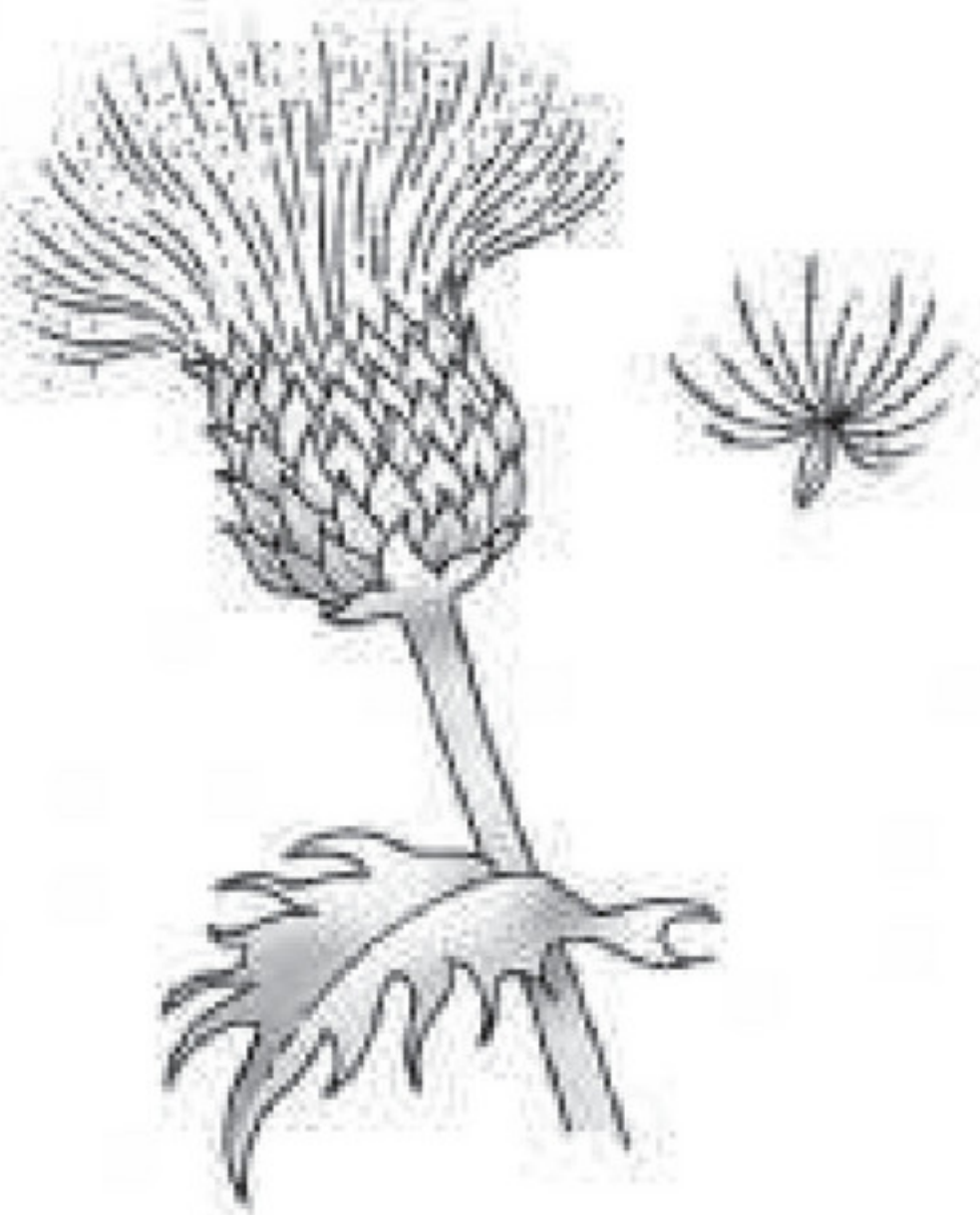
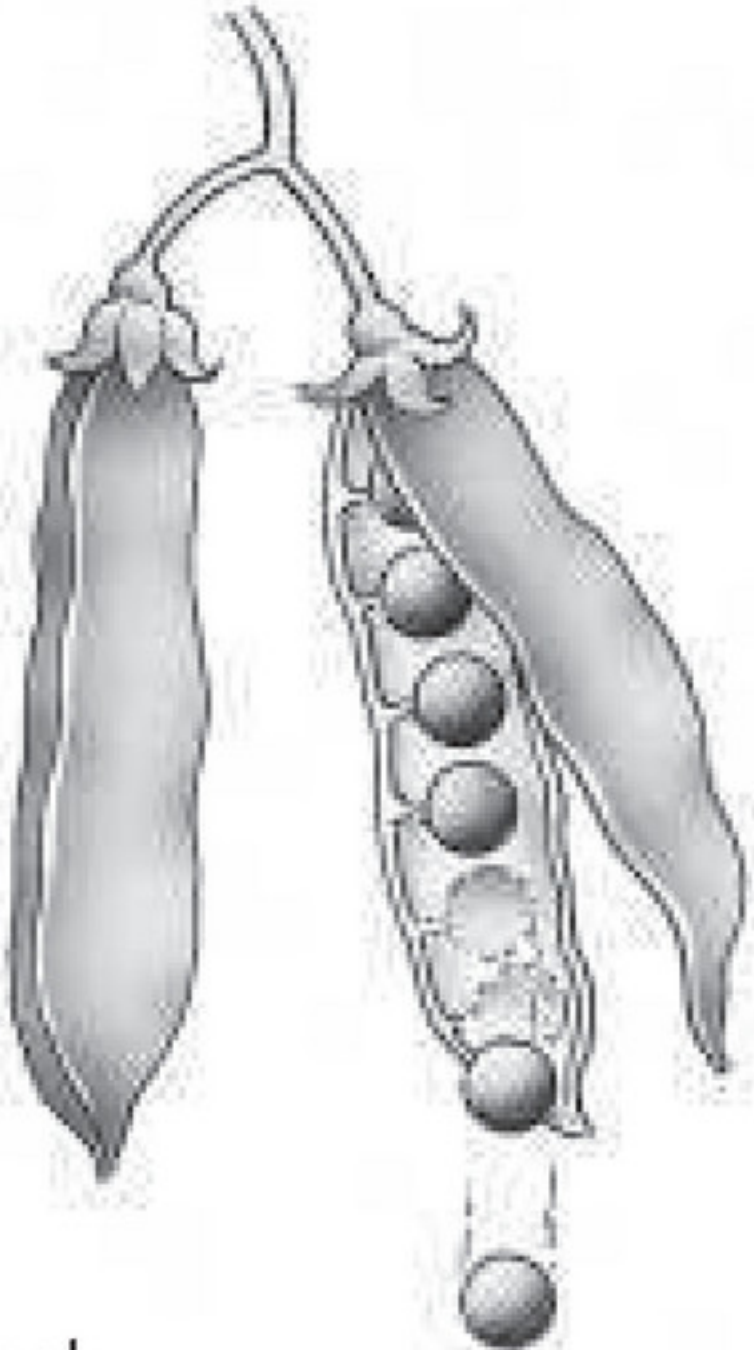
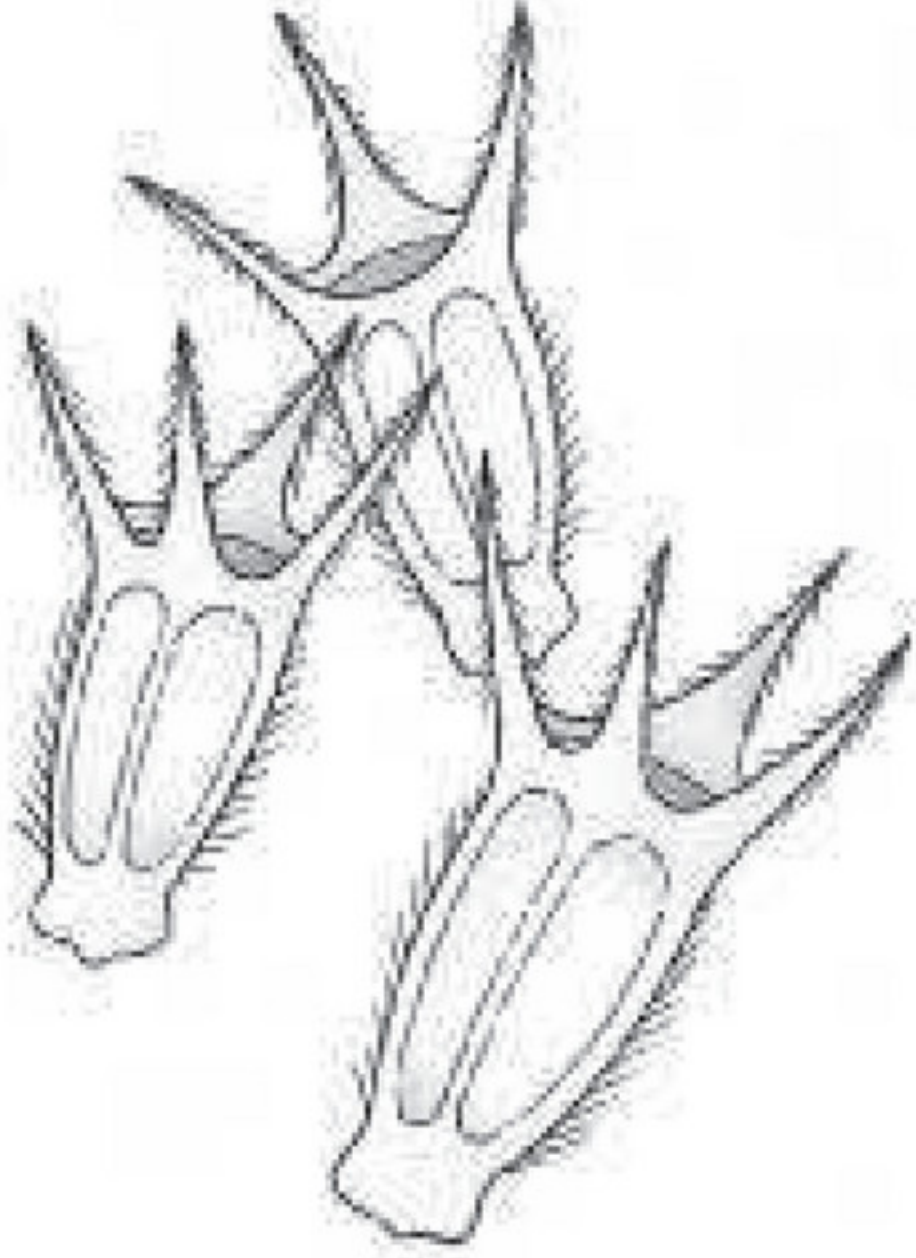
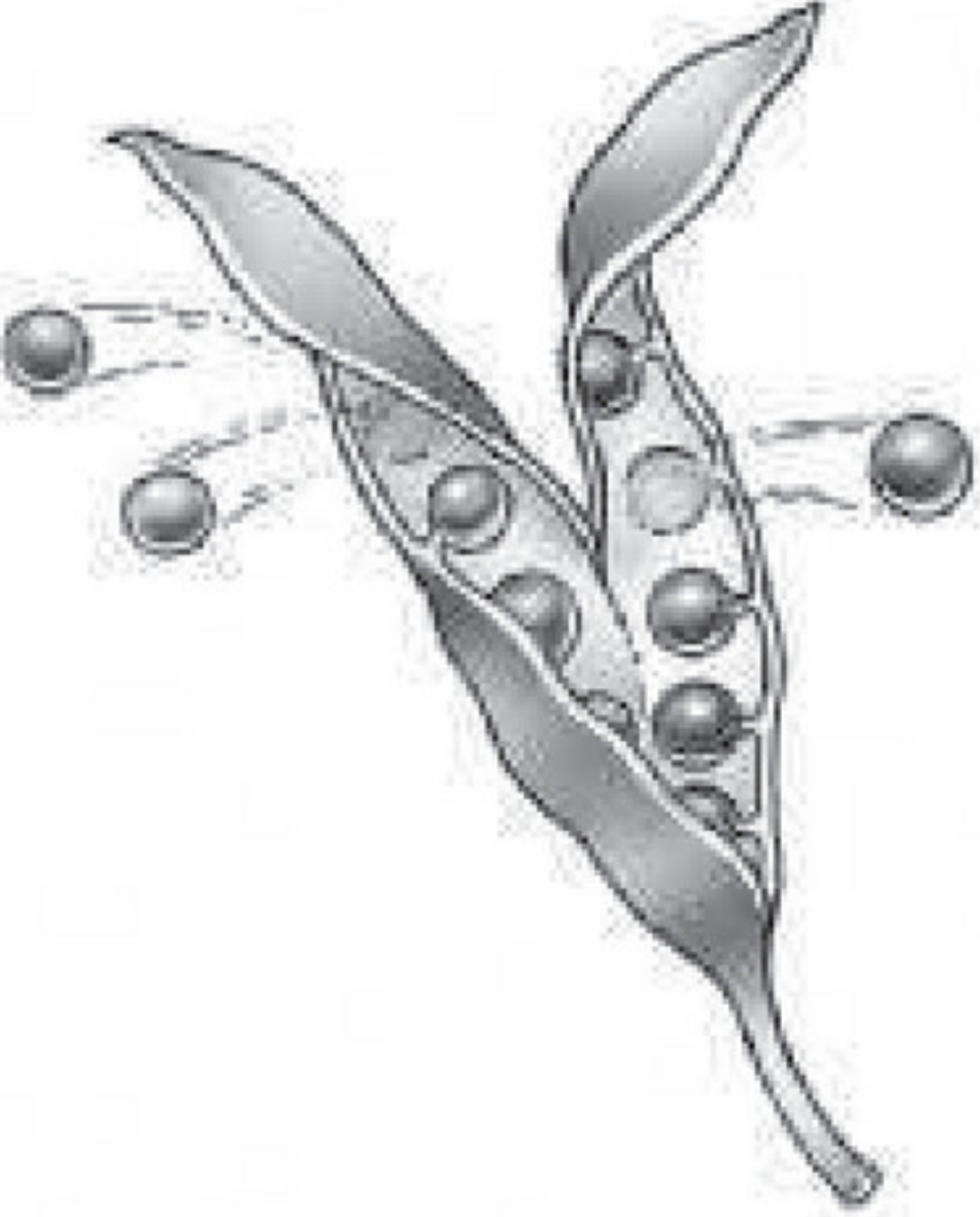
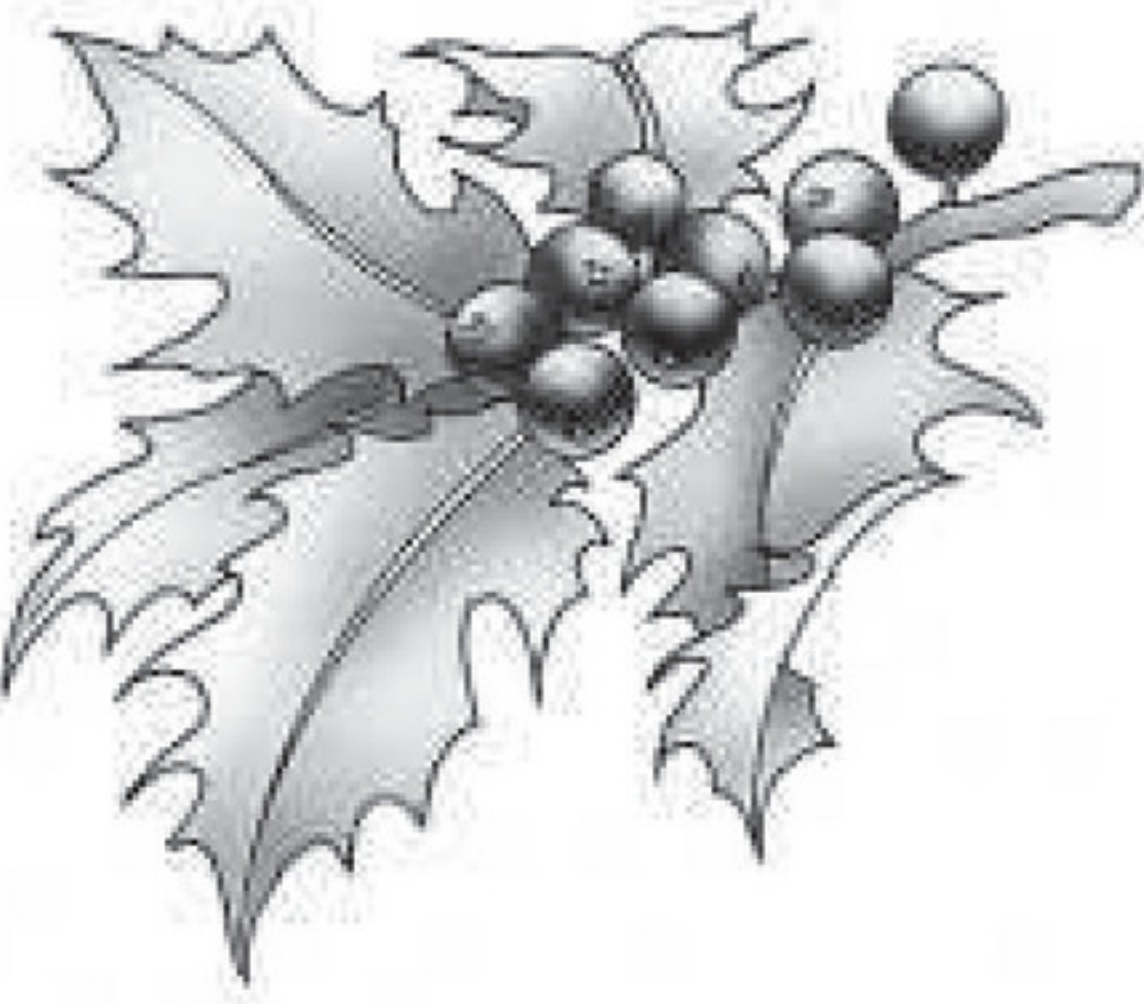
- a Why is it useful that the fruits and seeds of a plant get dispersed?
- b What method of seed dispersal scatters the seeds the least far? Explain your answer.
- c Which features do you expect to see in fruits and seeds that are dispersed by the wind?
 - ☐ A They contain a lot of stored food.
 - ☐ B They have fluff plumes.
 - ☐ C They have juicy pulp.
 - ☐ D They have wings.
 - ☐ E They are very light.
- d When you blow a dandelion clock, what are you actually blowing away?

3



Figure 7 shows various parts of plants containing fruits and seeds. For each picture, write down how the fruits and seeds are dispersed: by the plant itself, by the wind or by animals.

fig. 7

creeping thistle  dispersal:	pea  dispersal:	burr marigold  dispersal:
broom  dispersal:	ash  dispersal:	balsam  dispersal:
oak  dispersal:	holly  dispersal:	lime  dispersal:

 Go to the *Flash cards*.

8 Male and female organs

LEARNING OBJECTIVE

6.8.13 You can name male and female reproductive organs in plants and animals.

► Practical activity 10

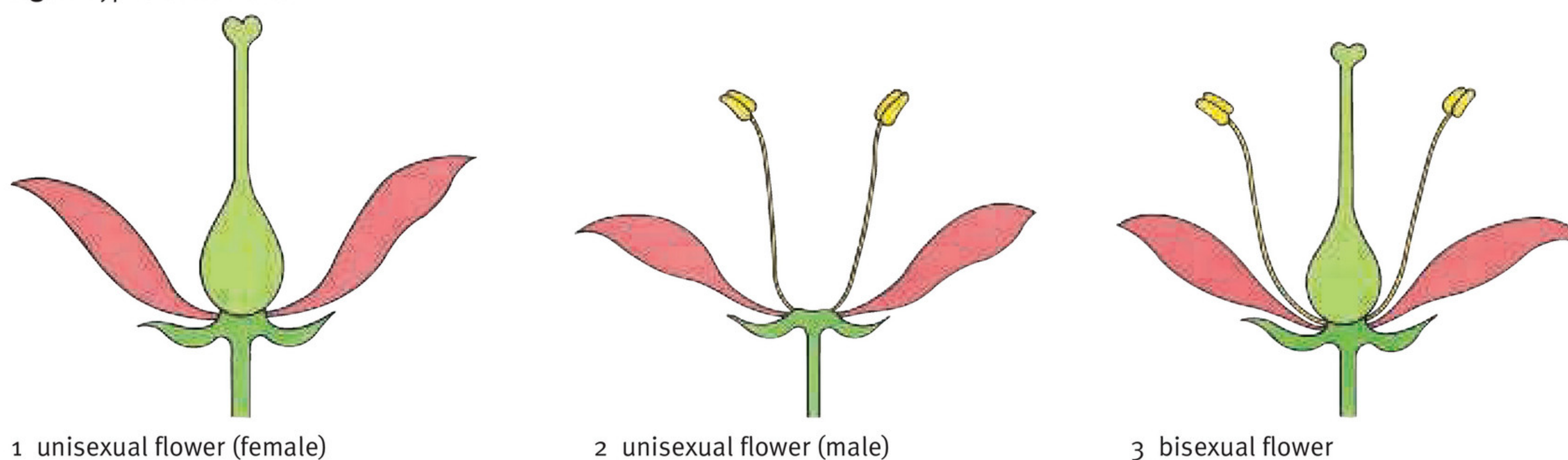
TAXONOMY	LEARNING OBJECTIVE AND EXERCISES
	6.8.13
Remembering	3a
Understanding	3bcde
Using	1, 2, 4, 5a
Analysing	5b

The stamens are the male reproductive organs of a plant. The carpel (pistil) is the female reproductive organ of a plant. Animals have reproductive organs too.

UNISEXUAL AND BISEXUAL FLOWERS

Most flowers have both stamens and carpels. These flowers are termed **bisexual**. In some plant species, each flower will have only stamens or only carpels. These flowers are called **unisexual** (see figure 1). Flowers that only have stamens are said to be male flowers. Flowers containing only carpels are referred to as female flowers.

fig. 1 Types of flowers.



MONOECIOUS AND DIOECIOUS SPECIES

Figure 2 shows a willow. A willow has clusters of unisexual flowers. A cluster of flowers like this is called a catkin. The catkins with stamens are called male catkins, and the catkins with carpels are called female catkins. A single willow tree has either only male catkins or only female catkins. Plant species in which the individual plants have either male flowers or female flowers (but not both) are called **dioecious**. Plant species in which both male and female flowers are found on the same plant are called **monoecious**. Plant species with bisexual flowers are always monoecious.

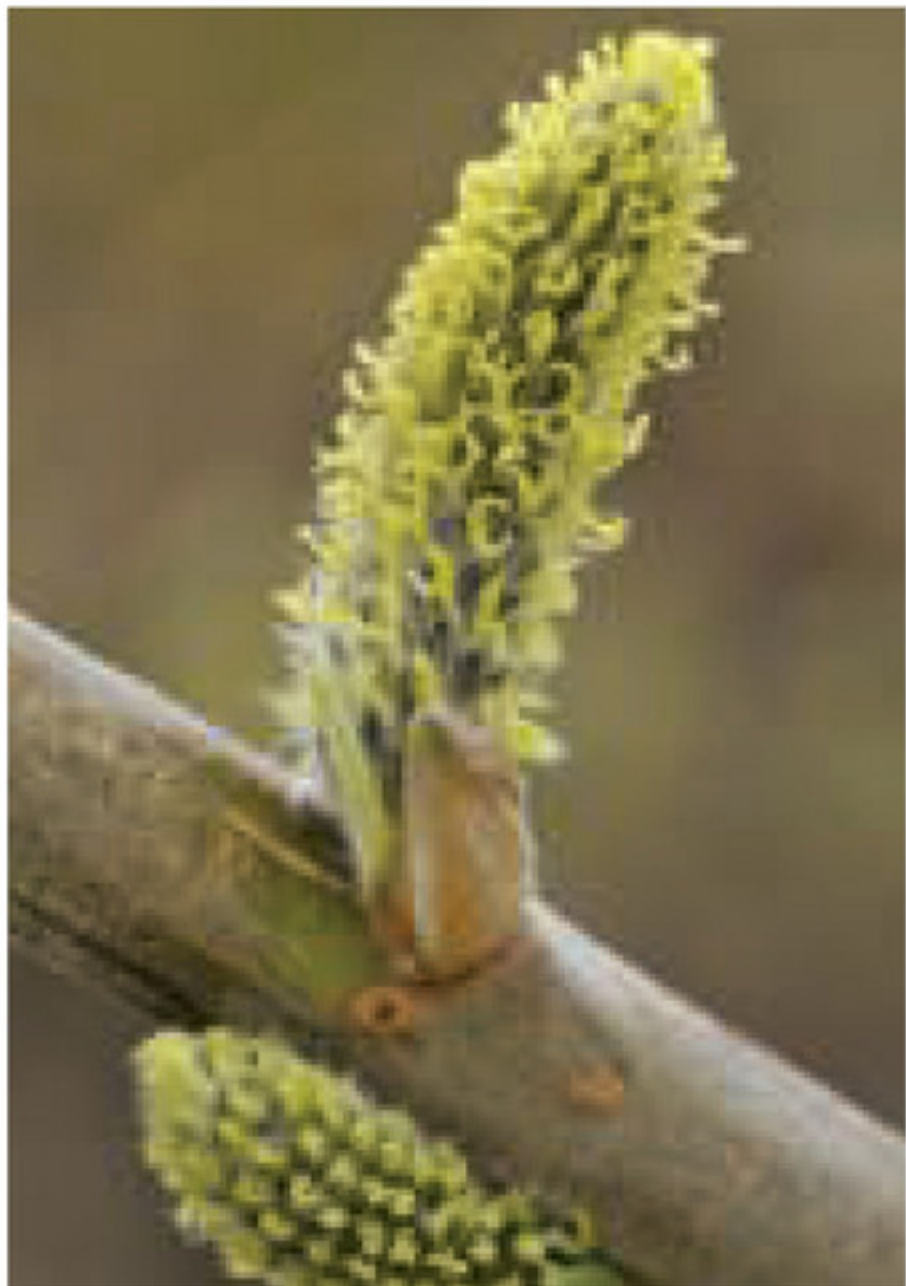
fig. 2



1 pollarded willows



2 male catkin

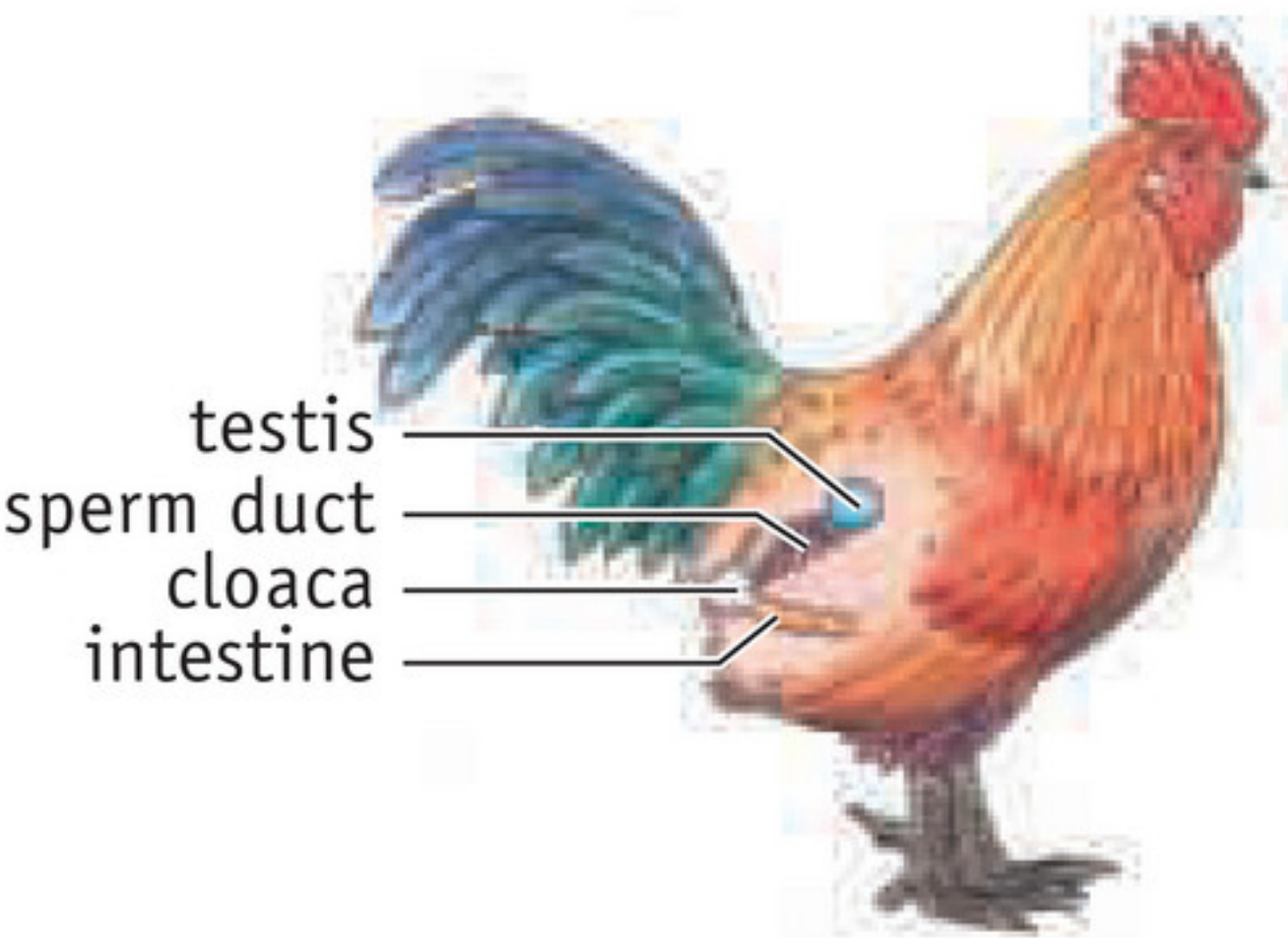


3 female catkin

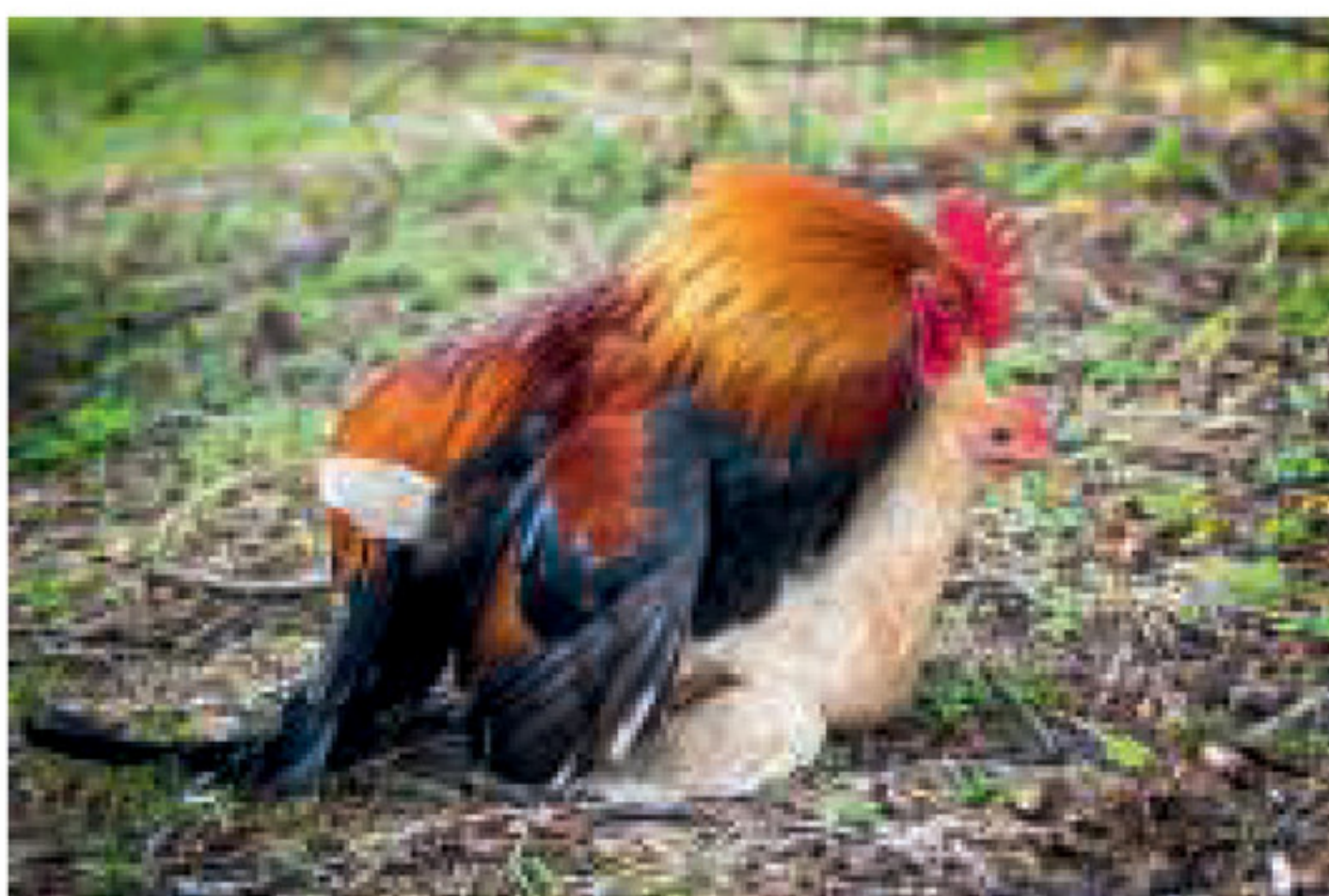
ANIMALS

Birds do have sex organs, but not on the outside. Both males and females have an opening in the lower body called a **cloaca** (Latin for a ‘sewer’). The sperm of males goes into their cloaca. In the female, the oviducts exit into the cloaca (see figure 3). In both sexes, the intestines and the ureters also exit into the cloaca. In the mating, the male and female press the cloacal openings together. Sperm cells can then reach the oviduct.

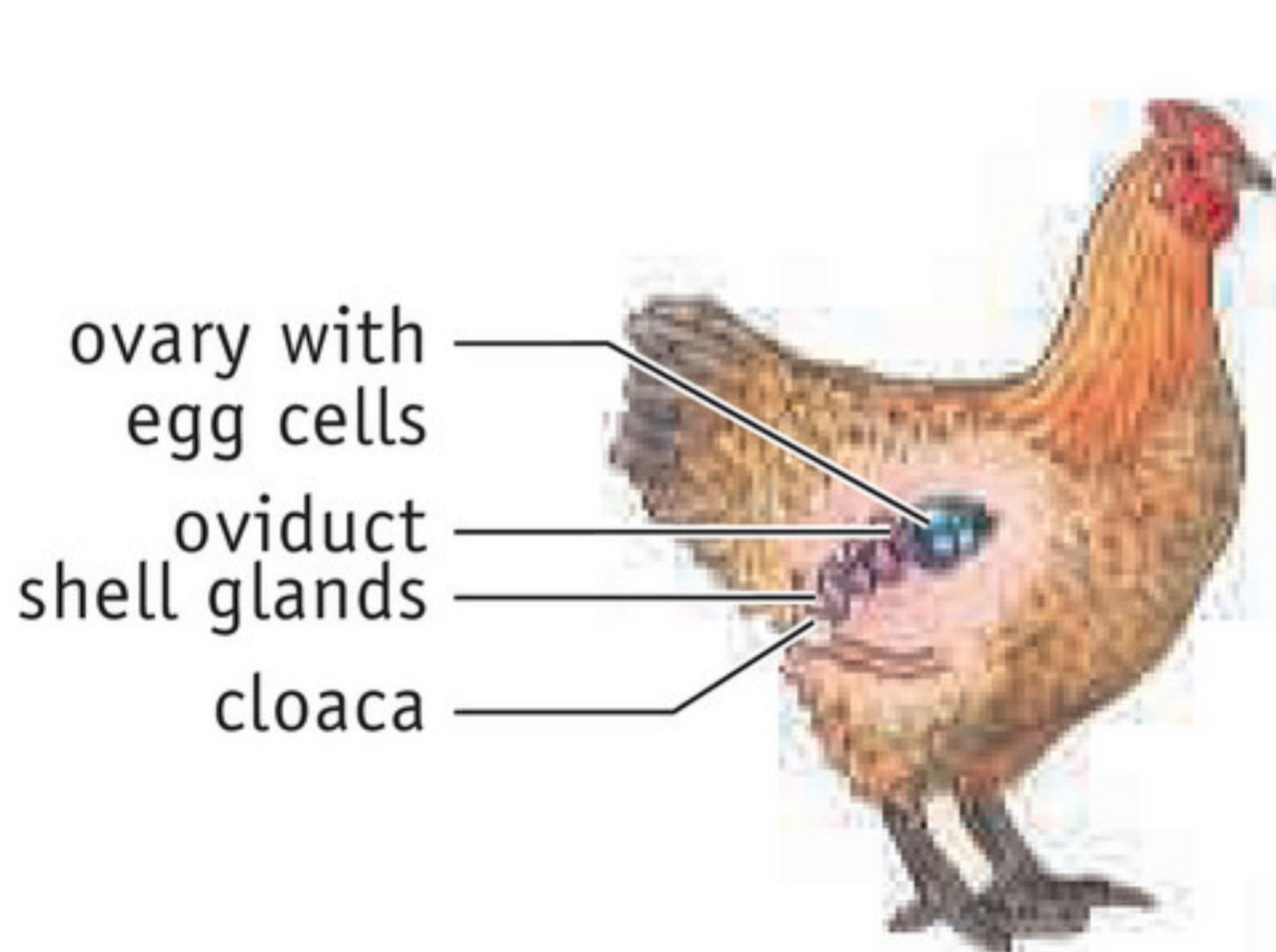
fig. 3 Birds have a cloaca.



1 rooster (male)



2



3 hen (female)

Reptiles use internal fertilization as well. Reptiles generally have a long tail, which makes mating more difficult. That's why male snakes and lizards have two penises. Each penis is called a **hemipenis** (see figure 4.1). These mean that the male can make contact with the female both to the left and to the right of the tail. One of the hemipenises penetrates the cloaca of the female (see figure 4.2).

fig. 4 Reproduction in lizards.



1 two hemipenises on a lizard



2 pretty awkward!

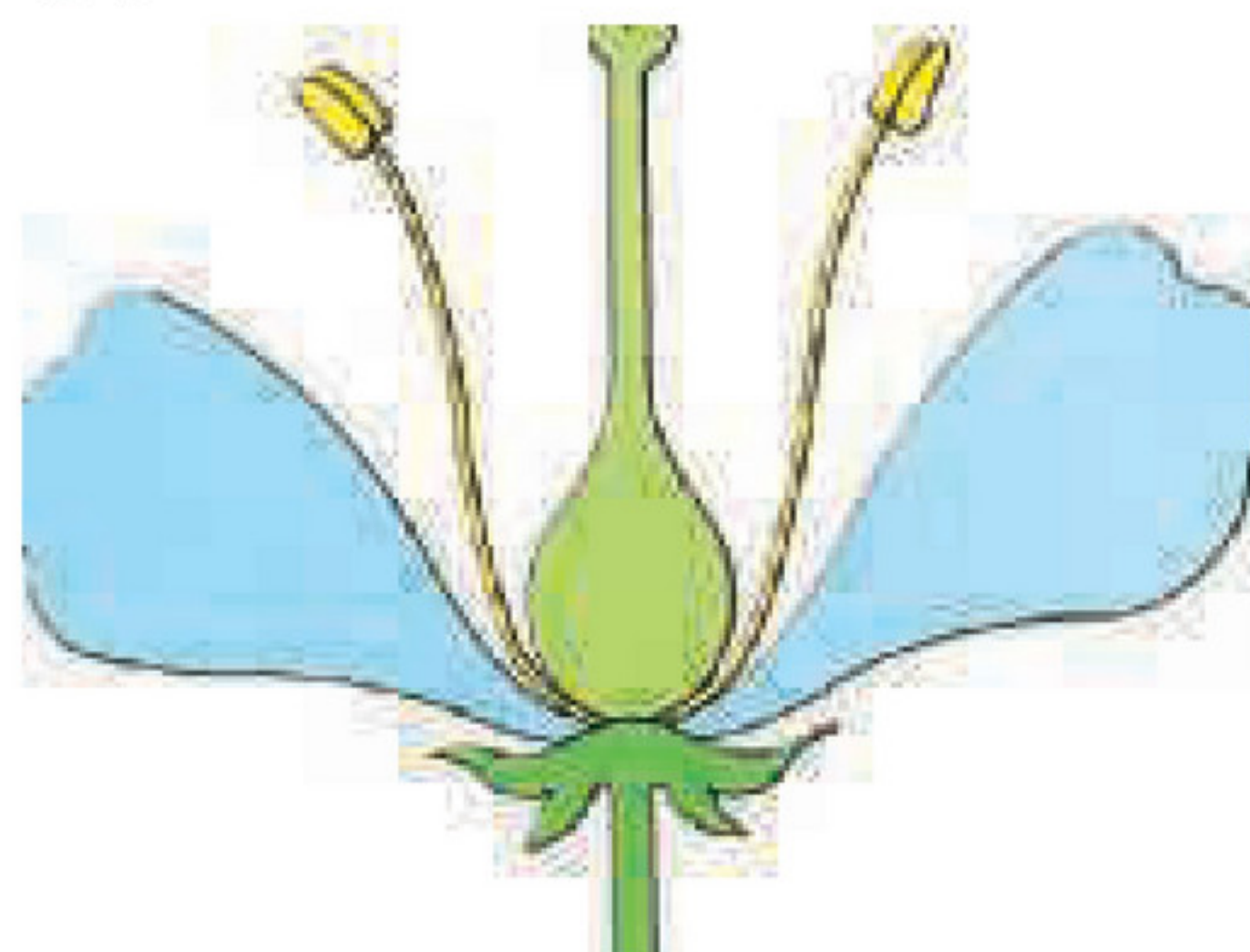
EXERCISES

1

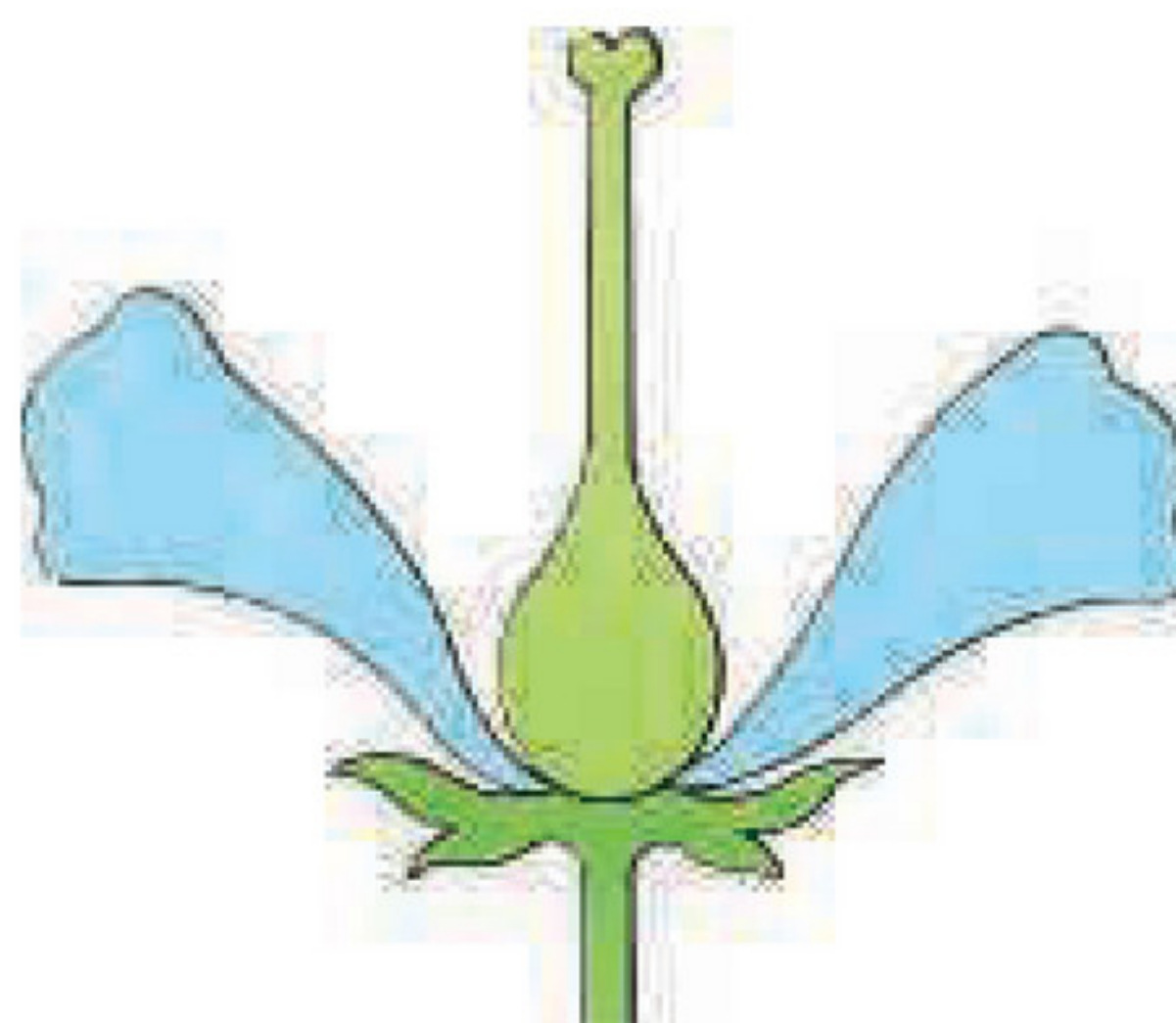
Have a look at figure 5.

- a Which flower (or flowers) can produce pollen? 1 / 2 / 3
- b Which of these flowers are unisexual? 1 / 2 / 3
- c A certain plant species has flowers of both type 2 and type 3 on the same plant. Is this plant species monoecious or dioecious? Explain your answer.

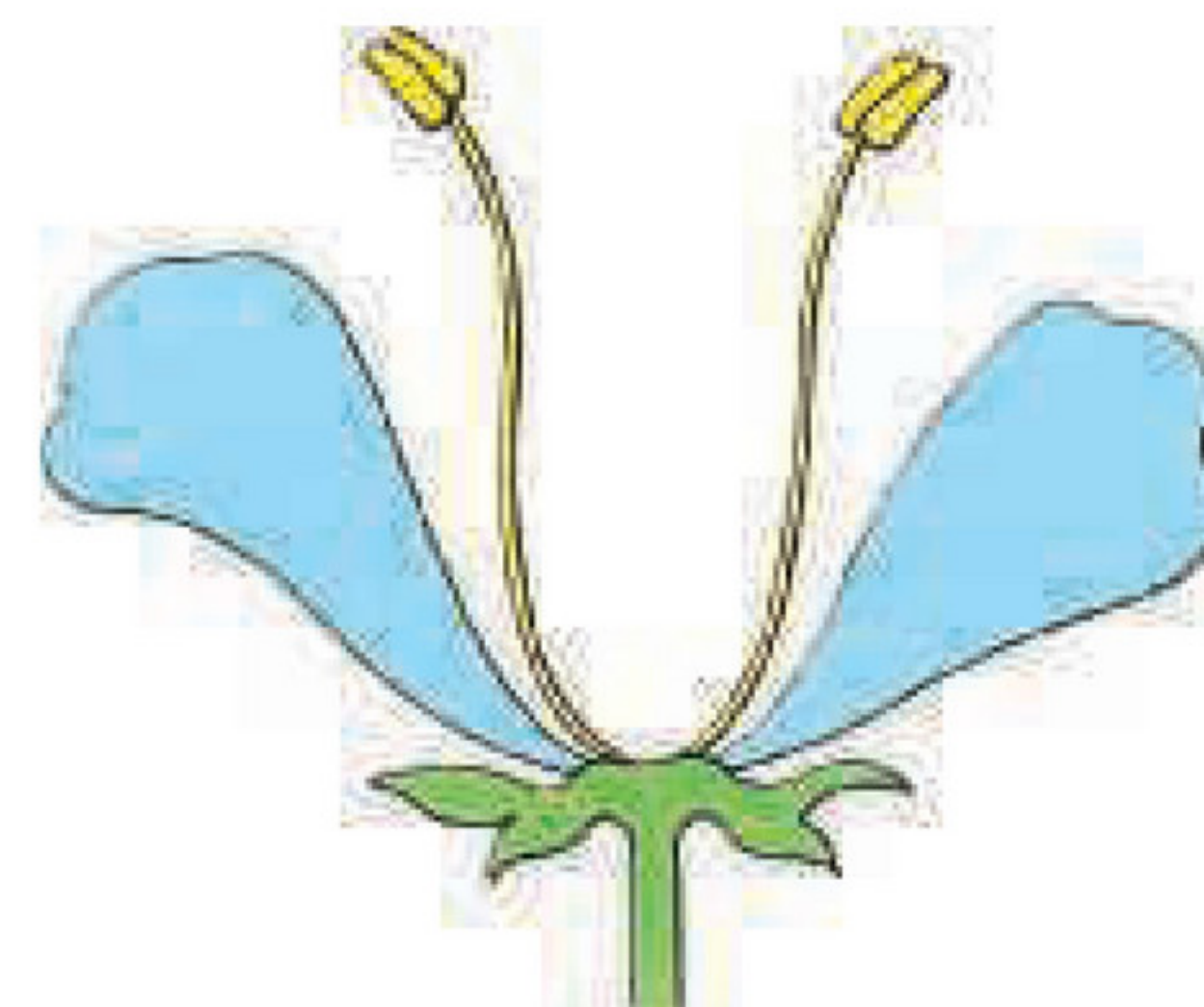
fig. 5



flower 1



flower 2



flower 3

2

- a Can self-pollination take place in a dioecious plant? Explain your answer.
- b Is self-pollination possible in a willow?

3

- a** Which organisms can have a hemipenis?
male / female / both
- b** The city aquarium in Antwerp had an iguana by the name of Mozart. Mozart had an inflammation on one of his hemipenises and the staff decided it would be best to amputate (remove it).
Was Mozart still able to fertilize females after the amputation? Explain your answer.
- c** Which organisms can have a cloaca?
male / female / both
- d** Which organs in birds exit into the cloaca?
- e** Male sharks have two protrusions between their ventral fins that are known as 'claspers'. They use the claspers when fertilizing a female shark.
What is a clasper most similar to?
- ☐ A cloaca
 - ☐ B hemipenis
 - ☐ C penis
 - ☐ D ovule

fig. 6 Claspers.



4

In some bird species, the males and females are very similar in both colouring and size. Explain why it is difficult to tell the males from the females in these species.

5

Most birds have a cloaca. In about 3% of known bird species, though, the male does have an external sex organ, known as a pseudopenis. One such bird is a South American stiff-tailed duck called the Argentine lake duck. Drakes (male ducks) of this species have a pseudopenis of 20 to as much as 40 cm in length.

- a** Is fertilization in the lake duck internal or external? Explain your answer.
- b** External sex organs in birds are found mostly in ducks.
Explain why such an organ is useful for ducks in particular.

 Go to the *Flash cards*.

Learning how to do research

1

GIVING A WRITTEN PRESENTATION OF AN INVESTIGATION

► Basics 2 | ► Learning objective 6.O.14

In science, researchers often do further work that is based on other people's findings. They share research results so that they can progress further together. There are two ways of doing it: verbally and in writing. In a verbal presentation, you tell others what you have done and what it has let you discover. A written presentation is a summary report on your research.

You always structure a report in the same way. Figure 1 tells you how to make a research report.

fig. 1

Making a research report

- 1 Give your study a title.
Put your name and the names of the people you have been working with under the title.
- 2 Write an introduction.
This is where you describe the problem that you wanted to investigate. You can also explain the subject in more detail.
- 3 Then you make sections in the report for each of the research steps.
 - Research question
 - Hypothesis
 - What do you need?
 - Work plan
 - Results
 - Conclusion

Written presentations should also have pictures. You can for instance take photos of your setup and show your results as a graph.

EXERCISE

1

You are going to think up a piece of experimental research for yourself and then carry it out and give a written presentation.

The subject of your research could fit in with this unit, Reproduction in plants and animals, but it may also be about something else. Your teacher will tell you.

- Think what you want to investigate. Discuss with your teacher whether that is a reasonable choice.
- Write down the study question and your hypothesis.
- Think up an experiment that you could use for answering the research question.
- Write down what you will need in the work plan. Figure 2 tells you the points you have to be careful about in a work plan.
- Get your teacher to check the research question, the hypothesis, the items you will need and the work plan.
- Carry out the experiment as set out in the work plan. Write down your results.

- Put your results in a table and/or graph, as stated in the work plan.
- Write down a conclusion that answers the research question.
- Make a report of the study.

fig. 2 Making a work plan.

Eight questions about your work plan

- 1** What will you be investigating?
- 2** What organism will you do the experiment with (and why are you using this species)?
- 3** How many organisms will you need for each group for reliable results?
- 4** What conditions are you going to subject the test group and the control group to?
- 5** How do you make sure that other factors are not having an effect?
- 6** What do you need for doing the experiment?
- 7** How will you determine the result of the experiment?
- 8** How will you represent the result of the experiment?



Practical activities

1

THE FLOWERS OF A WHITE DEADNETTLE

► Basics 1 | ► Learning objective 6.1.1

 20-30 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will study the flowers of a white deadnettle. Take the flower apart carefully.

WHAT DO YOU NEED?

- ☐ a flowering white deadnettle (see figure 1)
- ☐ sticky tape (or clear sticky-backed plastic)
- ☐ tweezers
- ☐ drawing materials

WORKING METHOD

- Pluck a single flower (with calyx and corolla) off the stem. Use the tweezers if necessary to pluck the whole flower off the stem.
- Stick it in the box below.
- Pluck another flower off the white deadnettle.
- Separate the corolla (the white part) and the calyx (the green part) from one another.
- Stick the corolla and the calyx in the box next to the flower.
- Pluck another flower off the white deadnettle.
- Bend the upper part of the corolla back. You can then see five filaments. Remove these filaments carefully from the flower (using the tweezers if necessary). You will see four threads with black tips. These are the stamens (see figure 1 in Basics 1). The fifth thread is forked at the end like a snake's tongue. This filament is part of the carpel. The lower part of the carpel of a white deadnettle breaks easily, so pulling the whole carpel out of the flower is tricky.
- Stick the stamens and part of the carpel in the box, below the calyx and corolla.

fig. 1 A white deadnettle.



2

THE FRUITS OF A WHITE DEADNETTLE

► Basics 1 | ► Learning objective 6.1.1

 15-25 minutes**WHAT ARE YOU GOING TO DO?**

In this practical activity, you will study and draw the fruits of a white deadnettle. Remember the drawing rules!

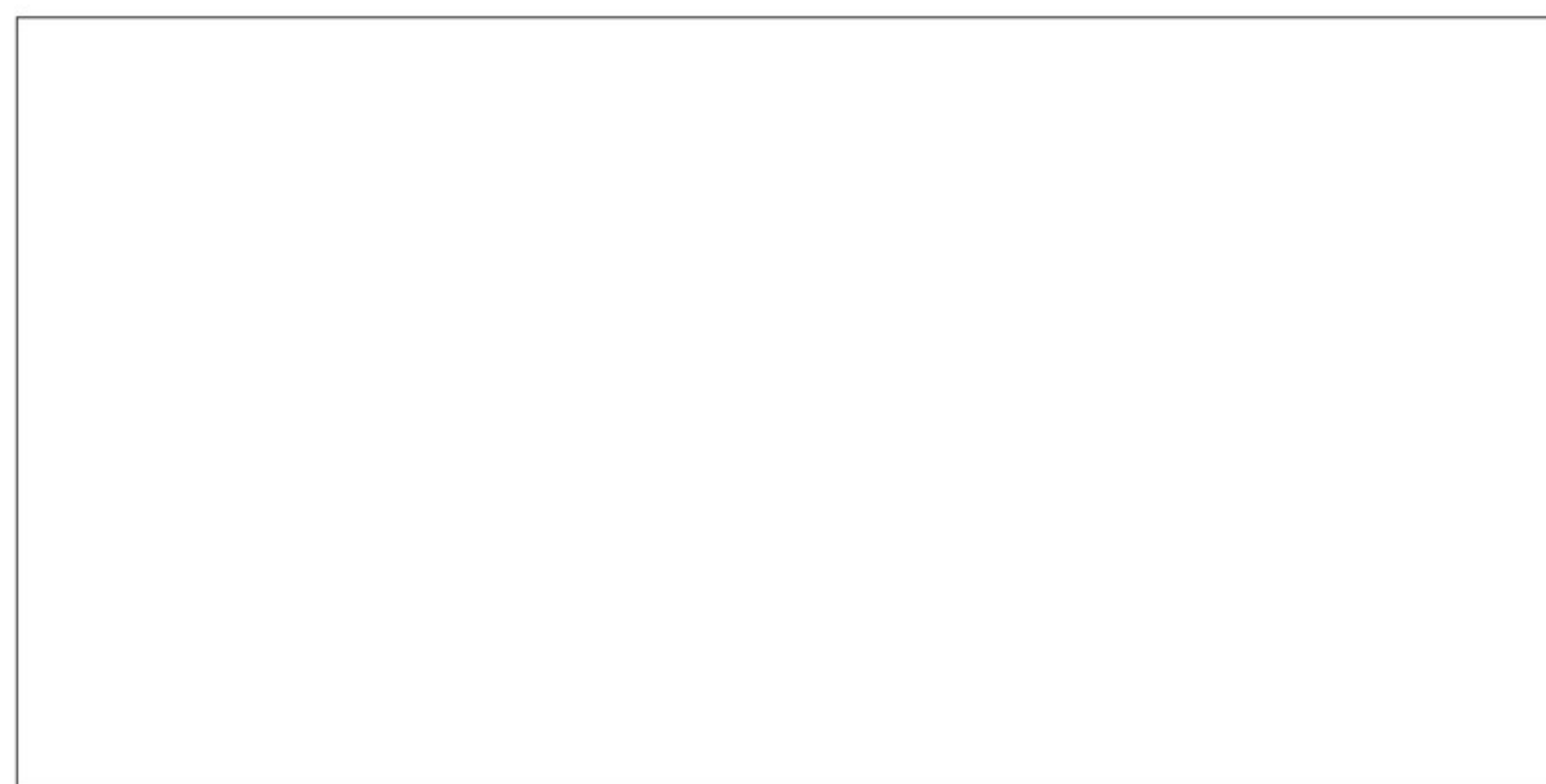
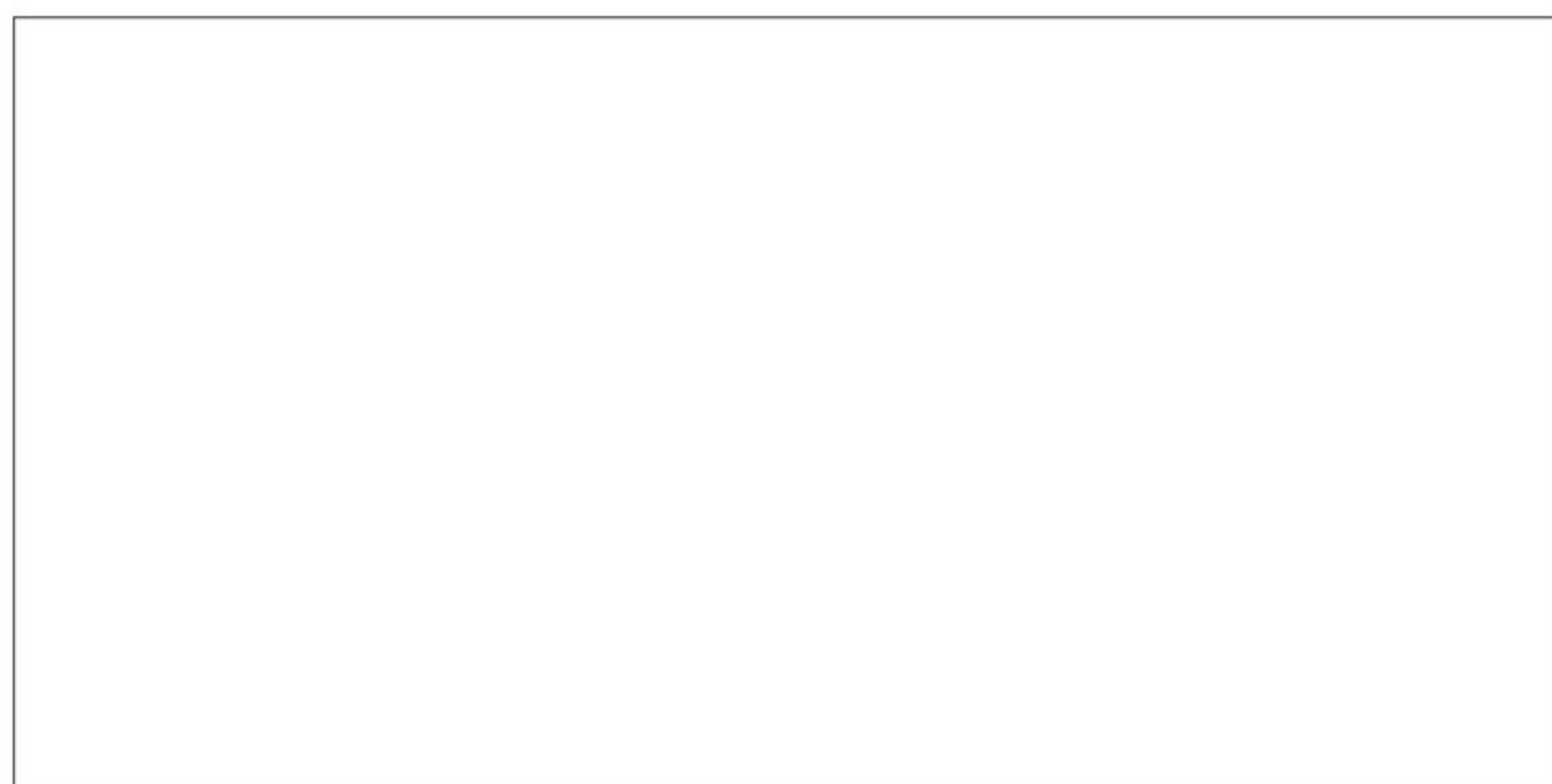
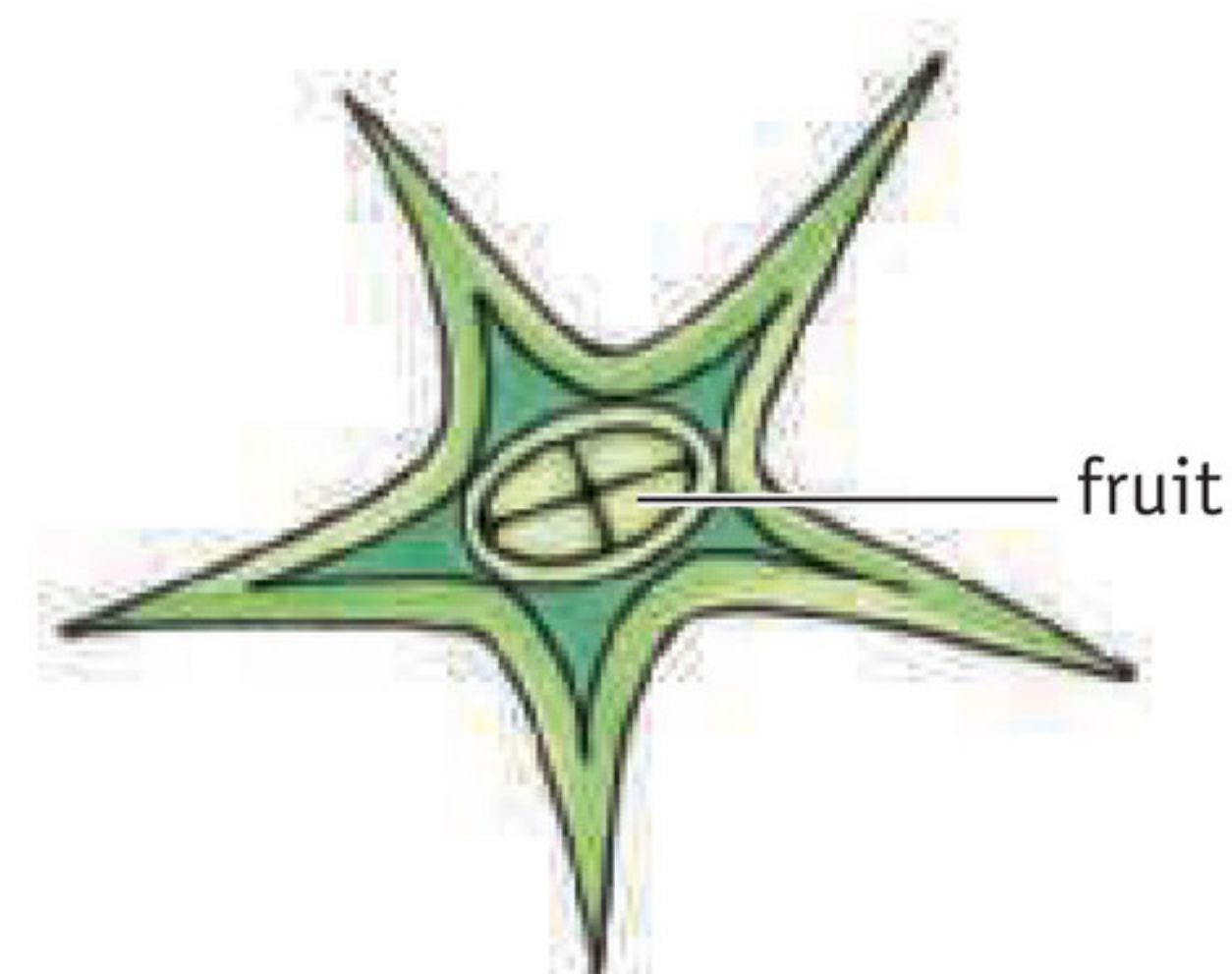
WHAT DO YOU NEED?

- ☐ a white deadnettle after flowering
- ☐ sticky tape (or clear sticky-backed plastic)
- ☐ tweezers
- ☐ drawing materials

WORKING METHOD

On the lower part of the flower stalk you will probably find some flowers that have finished flowering. The corollas have disappeared.

- Look inside a calyx. You will then see four fruits (see also figure 2). These fruits can be green, black or black. Each fruit contains a seed. This seed can grow into a new deadnettle.
- Make a true-to-life drawing of the location of the four fruits in the calyx.
- Use the tweezers to take the fruits out of the calyx and make a drawing of one fruit.

fig. 2 Calyx with fruits.

3

THE FLOWER OF A...

► Basics 1 | ► Learning objective 6.1.1

 30-40 minutes**WHAT ARE YOU GOING TO DO?**

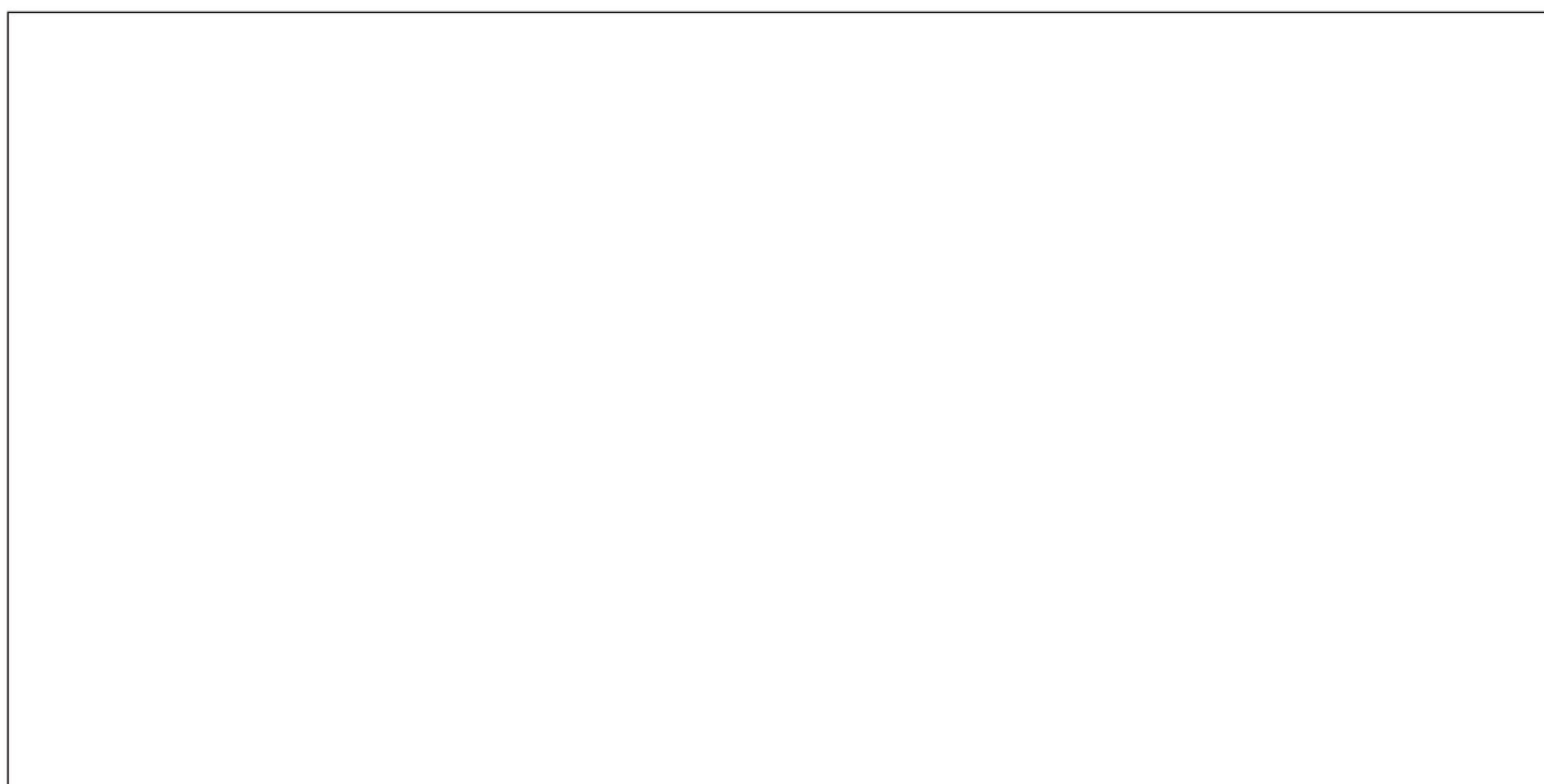
In this practical activity, you will be drawing various parts of a flower. Remember the drawing rules!

WHAT DO YOU NEED?

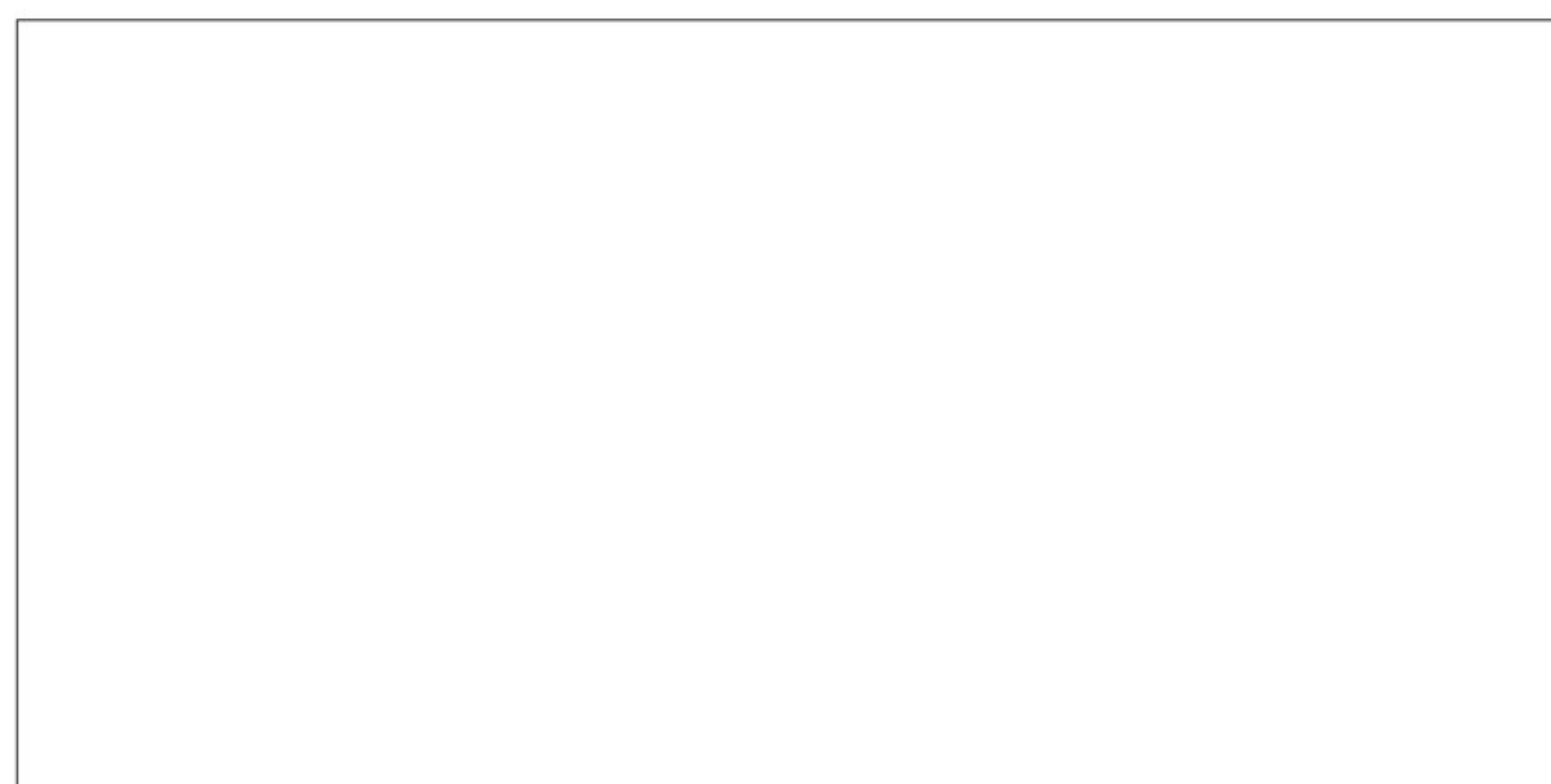
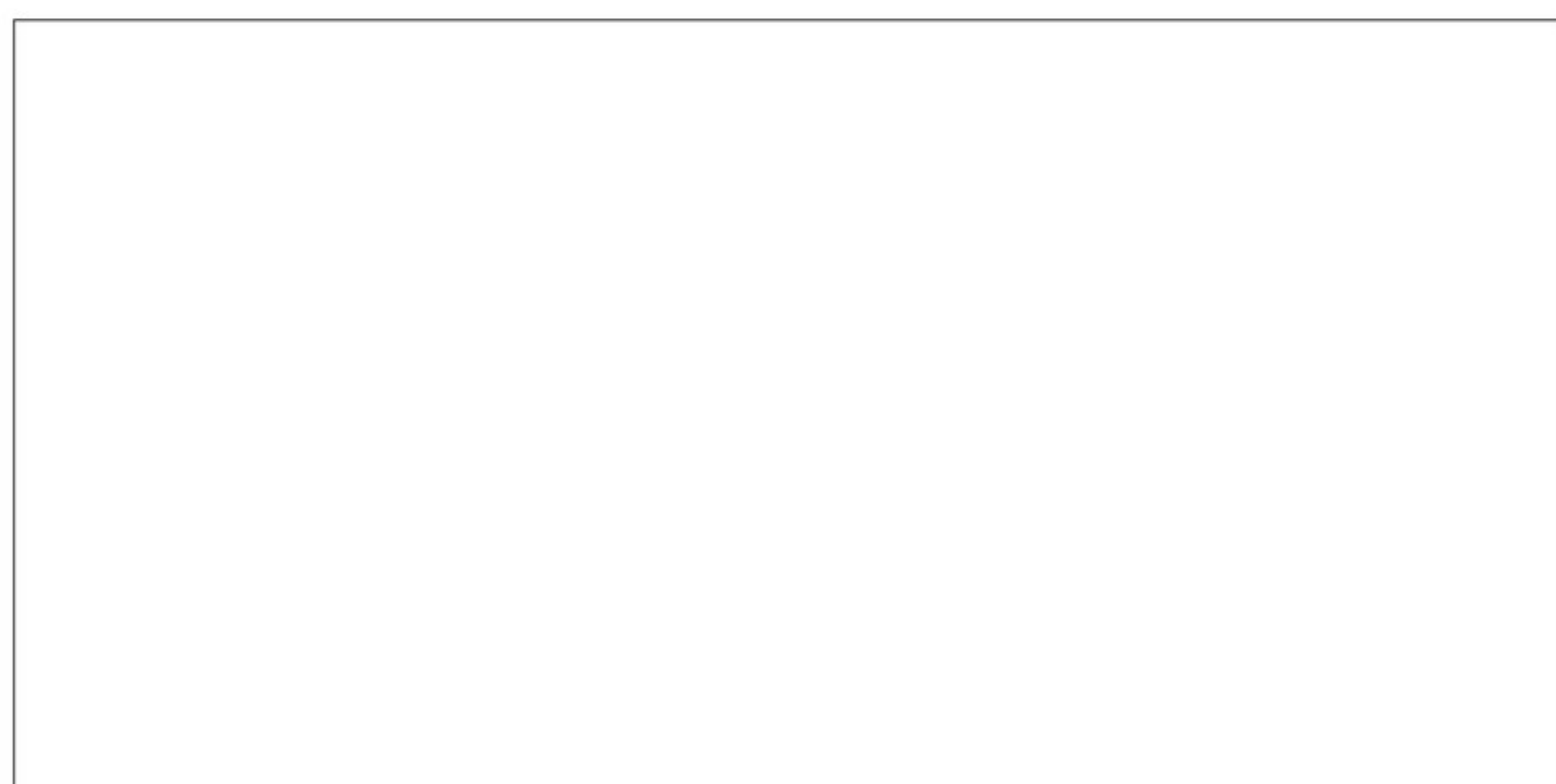
- ☐ a flowering plant
- ☐ tweezers (if necessary)
- ☐ drawing materials

WORKING METHOD

- Make a true-to-life drawing of the external view of the flower. Write down what flower you have drawn. Label the following parts: *stalk – sepal – petal*.



- Carefully remove a stamen from the flower. Use the tweezers for this if necessary.
- Make a true-to-life drawing of the stamen. Label the following parts: *filament – anther*.
- Carefully remove the carpel from the flower (or one of the carpels, if it has several). Use the tweezers for this if necessary.
- Make a true-to-life drawing of the carpel. Label the following parts: *stigma – style – ovary*.



4

HAY FEVER

► Basics 2 | ► Learning objectives 6.2.4 and 6.O.14 | ► Learning how to do research 1

 20-30 minutes

WHAT ARE YOU GOING TO DO?

A lot of people suffer from hay fever. These people get an allergic response if they inhale the pollen grains of certain plants. It is important for them to know when plants of these species will be flowering. They can see this in a pollen calendar (see figure 3).
In this practical activity, you are going to investigate whether hay fever is caused by the pollen of insect-pollinated flowers and/or by the pollen of wind-pollinated flowers.

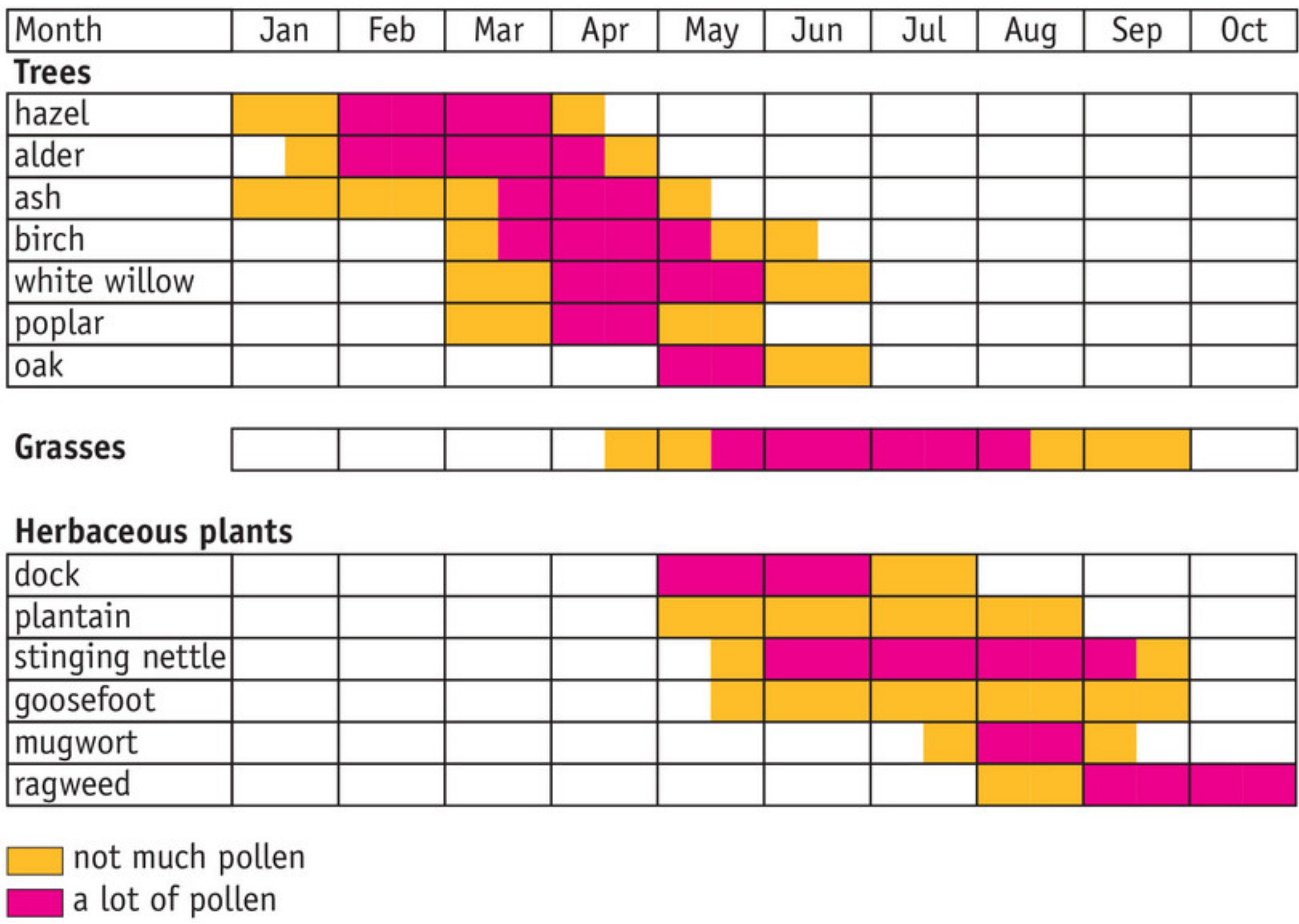
WHAT DO YOU NEED?

The table shows you what you will need.

WORKING METHOD

- Write down your study question and your hypothesis in the table.
- Do what it says in the work plan.
- Write down the results in a table and draw a conclusion.
- Make a report of the study. “Learning how to do research 1” tells you what to look out for.
- Hand the report in to your teacher.

fig. 3 Pollen calendar.



RESEARCH	HAY FEVER
Study question	
Hypothesis	
What do you need?	☐ access to the Internet or a plant species guide
Work plan	• Look up the plants that are in the pollen calendar. • For each plant, write down whether its flowers are insect-pollinated or wind-pollinated.
Results	• Show your results in a table.
Conclusion	

5

POLLEN GRAINS

► Basics 2 | ► Learning objective 6.2.4

 15-25 minutes**WHAT ARE YOU GOING TO DO?**

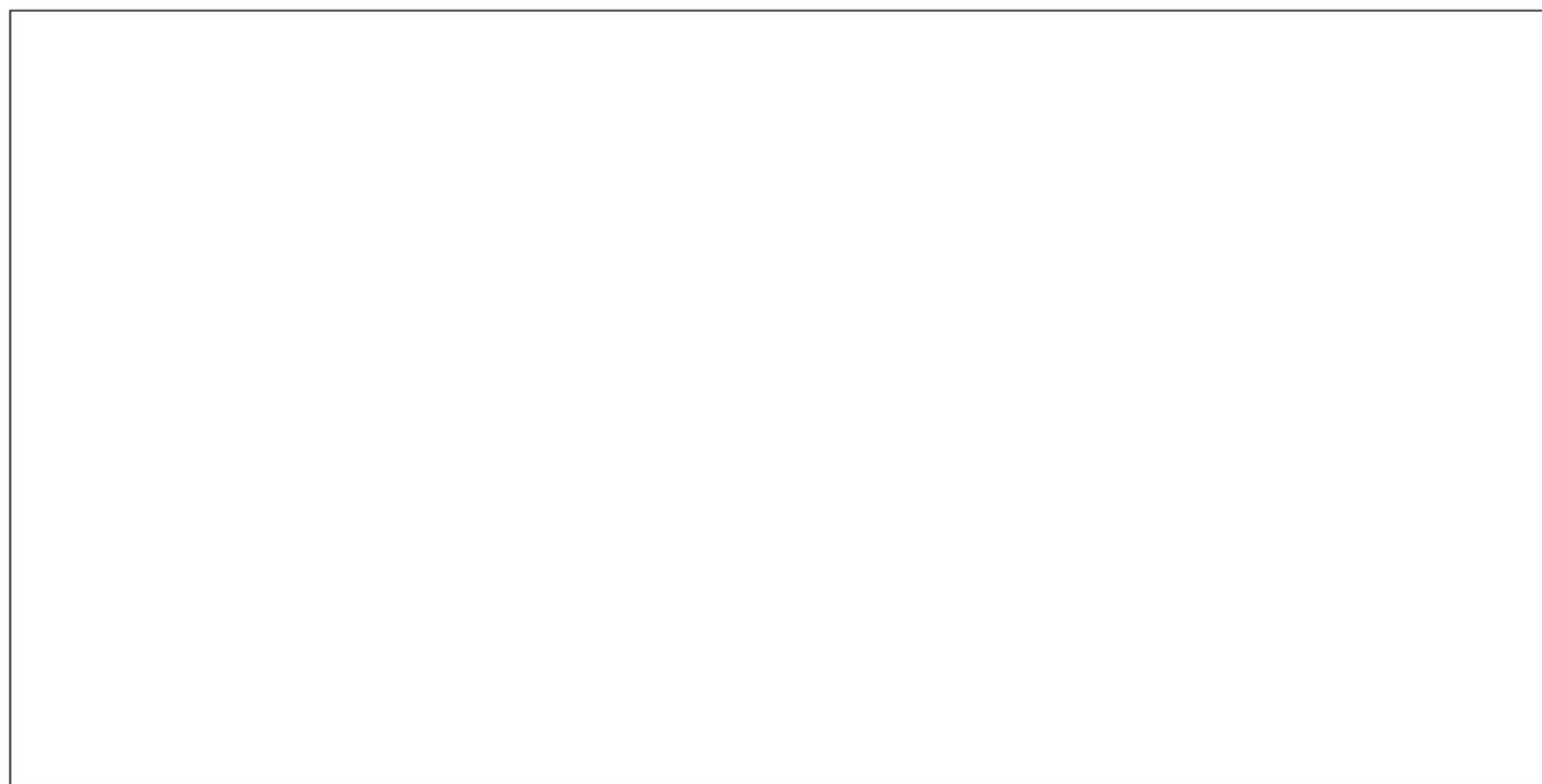
In this practical activity, you will be studying pollen grains of insect-pollinated and wind-pollinated flowers. You will make drawings. Remember the drawing rules!

WHAT DO YOU NEED?

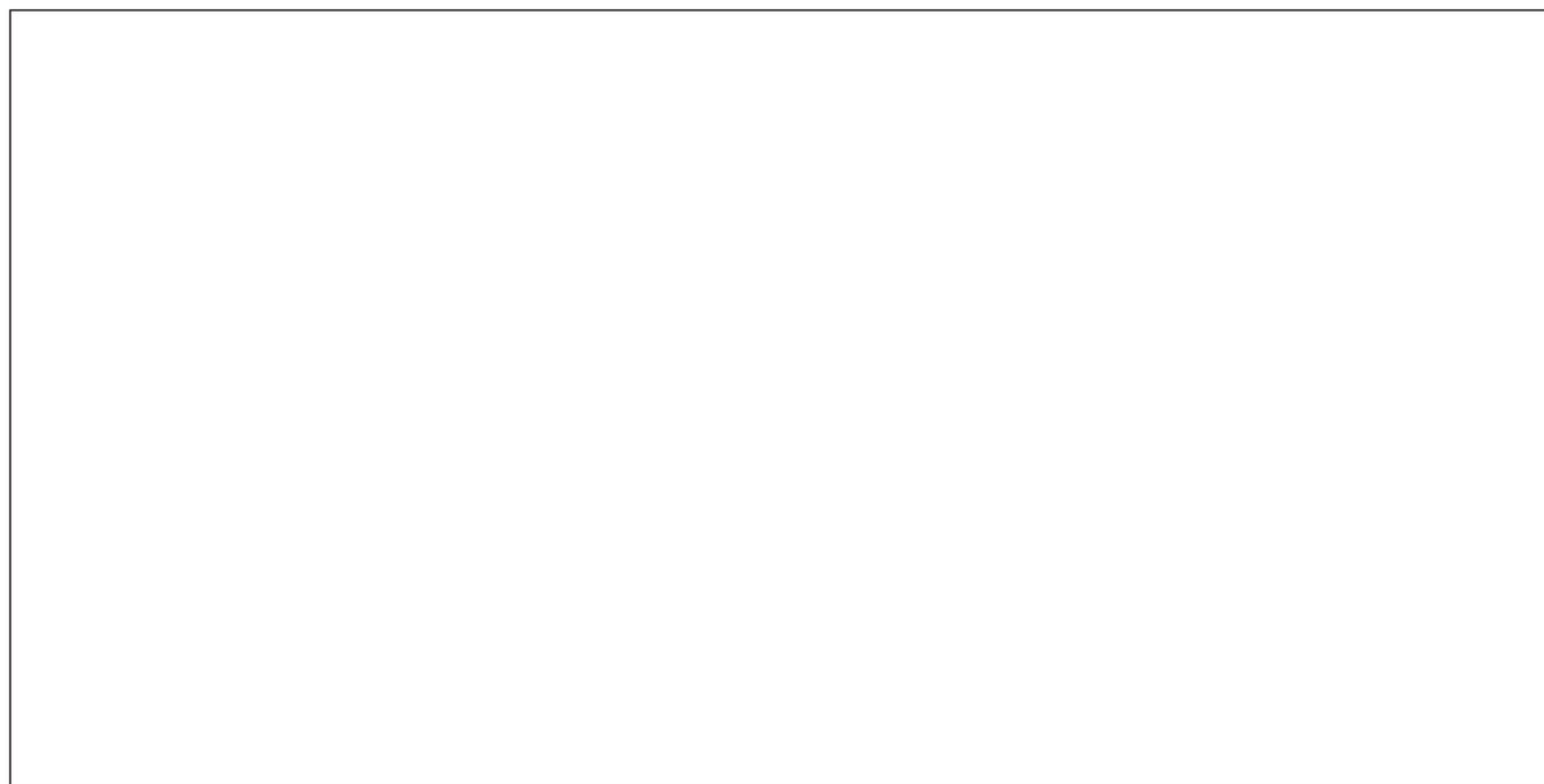
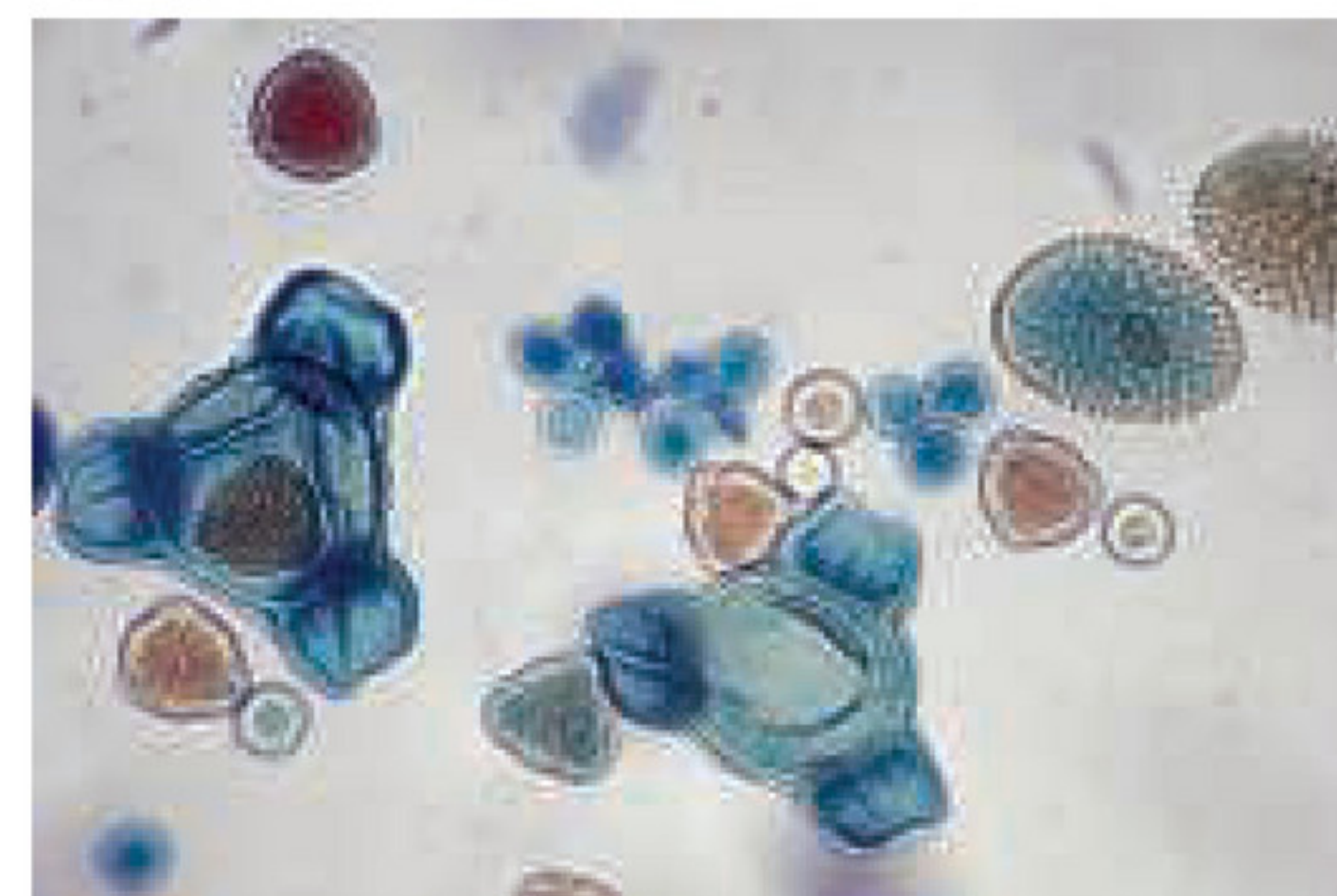
- ☐ a prepared specimen slide of pollen grains of various species of plants (see figure 4)
- ☐ a microscope
- ☐ drawing materials

WORKING METHOD

- Examine the specimen under the microscope at 400× magnification. You will see pollen grains of insect-pollinated and wind-pollinated flowers.
- Make a true-to-life drawing of at least two different pollen grains from insect-pollinated plants.



- Make a true-to-life drawing of at least two different pollen grains from wind-pollinated plants.

**fig. 4** Pollen grains.

6

A POLLEN TUBE

► Basics 3 | ► Learning objective 6.3.5

 35-45 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will be making a preparation of pollen grains. You will draw a pollen grain with a pollen tube. Remember the drawing rules!

WHAT DO YOU NEED?

- ☐ a sugar solution (5%)
- ☐ pollen, for example from a Busy Lizzie (see figure 5)
- ☐ a microscope
- ☐ preparation materials
- ☐ drawing materials

fig. 5 Busy Lizzie.

**WORKING METHOD**

- Put a drop of the sugar solution on a slide.
- Sprinkle some pollen grains over the sugar solution.
- Lay a cover slip carefully over the drop of sugar solution.
- Examine the specimen after 10 minutes using 100× magnification. Search the specimen for a pollen grain that has formed a pollen tube. Examine that pollen grain at a magnification of 400×.
- Make a true-to-life drawing of the pollen grain with a pollen tube.

7

A TOMATO

► Basics 4 | ► Learning objective 6.4.7

 10-15 minutes**WHAT ARE YOU GOING TO DO?**

In this practical activity, you will be drawing a cross-section of a tomato.

WHAT DO YOU NEED?

- ☐ a tomato
- ☐ a knife
- ☐ drawing materials

WORKING METHOD

- Cut the tomato vertically (down from the stalk) (see figure 6).
- Make a true-to-life drawing of the cross section of the tomato. Label the following parts: *fruit* – *seed*.

fig. 6



8

AN ONION BULB

► Basics 5 | ► Learning objective 6.5.9

 10-20 minutes

WHAT ARE YOU GOING TO DO?

In this practical activity, you will be drawing a lengthwise cross-section of an onion bulb.

fig. 7

**WHAT DO YOU NEED?**

- ☐ an onion bulb
- ☐ a knife
- ☐ drawing materials

WORKING METHOD

- Cut the onion bulb in half lengthwise (see figure 7).
- Make a true-to-life drawing of the lengthwise cross-section. Label the following parts:
bulb base – bud – food storage leaf – root.

9

THE DANDELION

▶ Extra 7 | ▶ Learning objective 6.7.12

 25-35 minutes**WHAT ARE YOU GOING TO DO?**

In this practical activity, you will be drawing various parts of a dandelion.

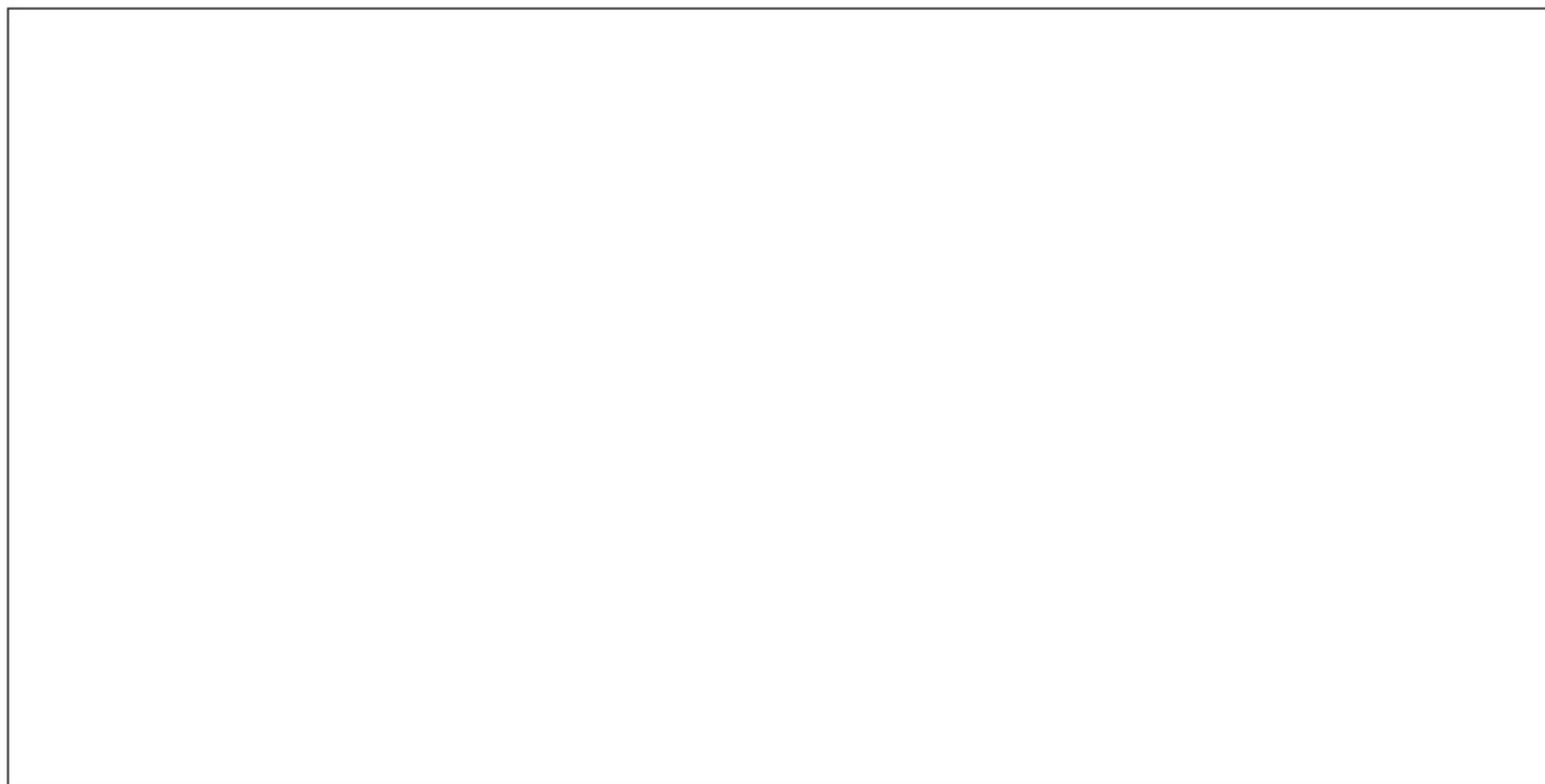
WHAT DO YOU NEED?

- ☐ one or more dandelions (parts that are flowering and that have finished flowering)
- ☐ tweezers
- ☐ a magnifying glass
- ☐ sticky tape
- ☐ drawing materials

WORKING METHOD

The flowering part of a dandelion consists of a large number of ray florets. Each calyx consists of several hairs. These hairs will become the fluff on the fruit once the flower has bloomed. The petals are fused.

- Break a flowering part in half and carefully remove a single floret from it with the tweezers.
- Examine the floret under a magnifying glass.
- Make a true-to-life drawing of a single ray floret. Label the following parts: *calyx* – *anthers* – *petals* – *stigma* – *style* – *ovary*.
- Stick the floret in next to your drawing.



Once a flower has finished blooming, the petals, the stamens and the style plus stigma fall off. The ovary then grows to become a fruit. The calyx forms a plume of fluff. The fruits are attached for a common flower receptacle.

- Examine part of a dandelion that has finished flowering.
- Pluck a single fruit and its fluff from the flower receptacle.
- Examine the fruit under a magnifying glass.
- Make a true-to-life drawing of the fruit and its fluff. Label the following parts: *fluff* – *fruit*.
- Stick the fruit in next to your drawing.



10

PLANTS WITH CATKINS

▶ Extra 8 | ▶ Learning objective 6.8.13

 10-20 minutes**WHAT ARE YOU GOING TO DO?**

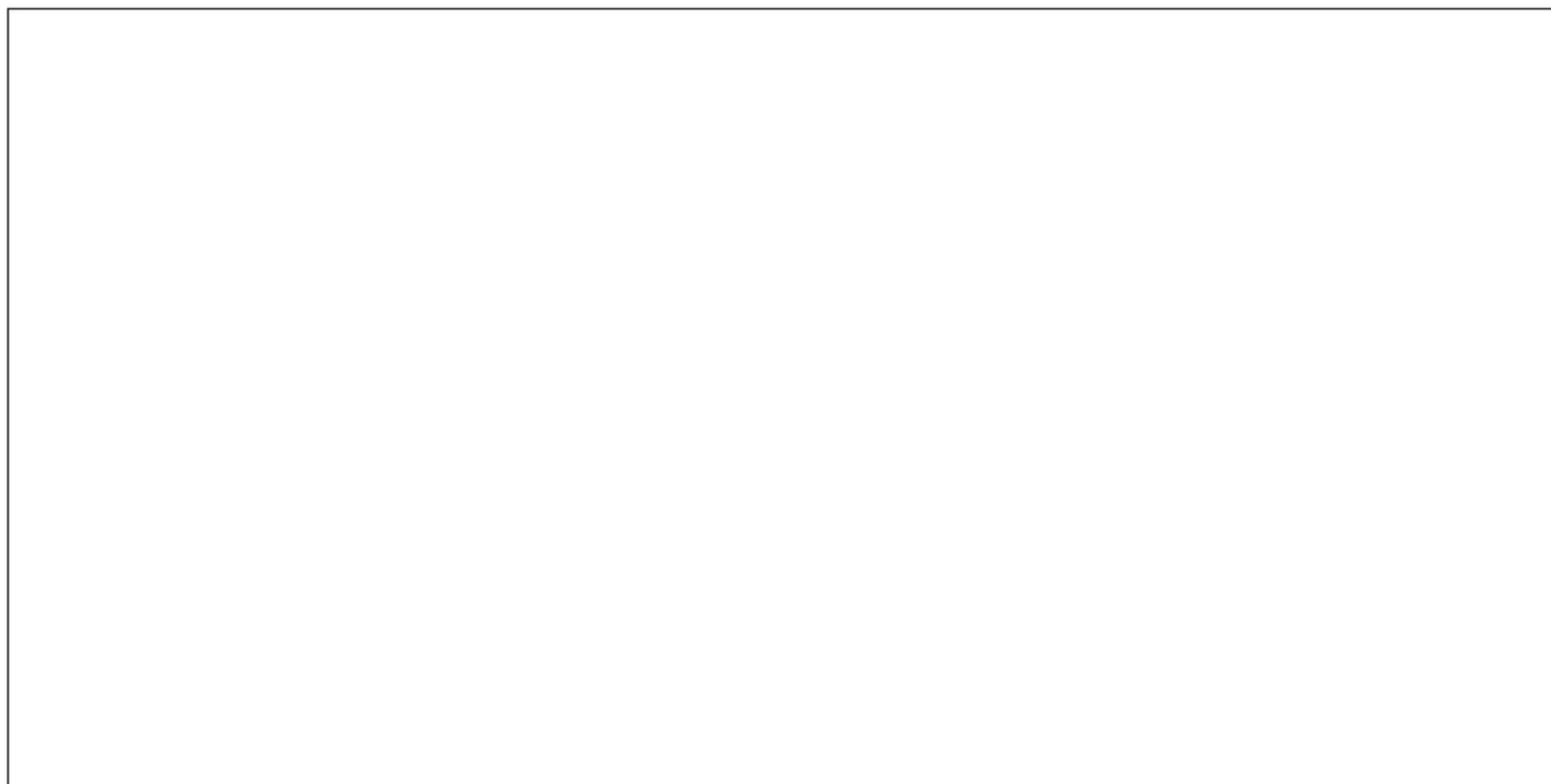
In this practical activity, you are going to examine and draw some catkins. Most plants with catkins bloom early in the spring. The fruits appear later in the spring.

WHAT DO YOU NEED?

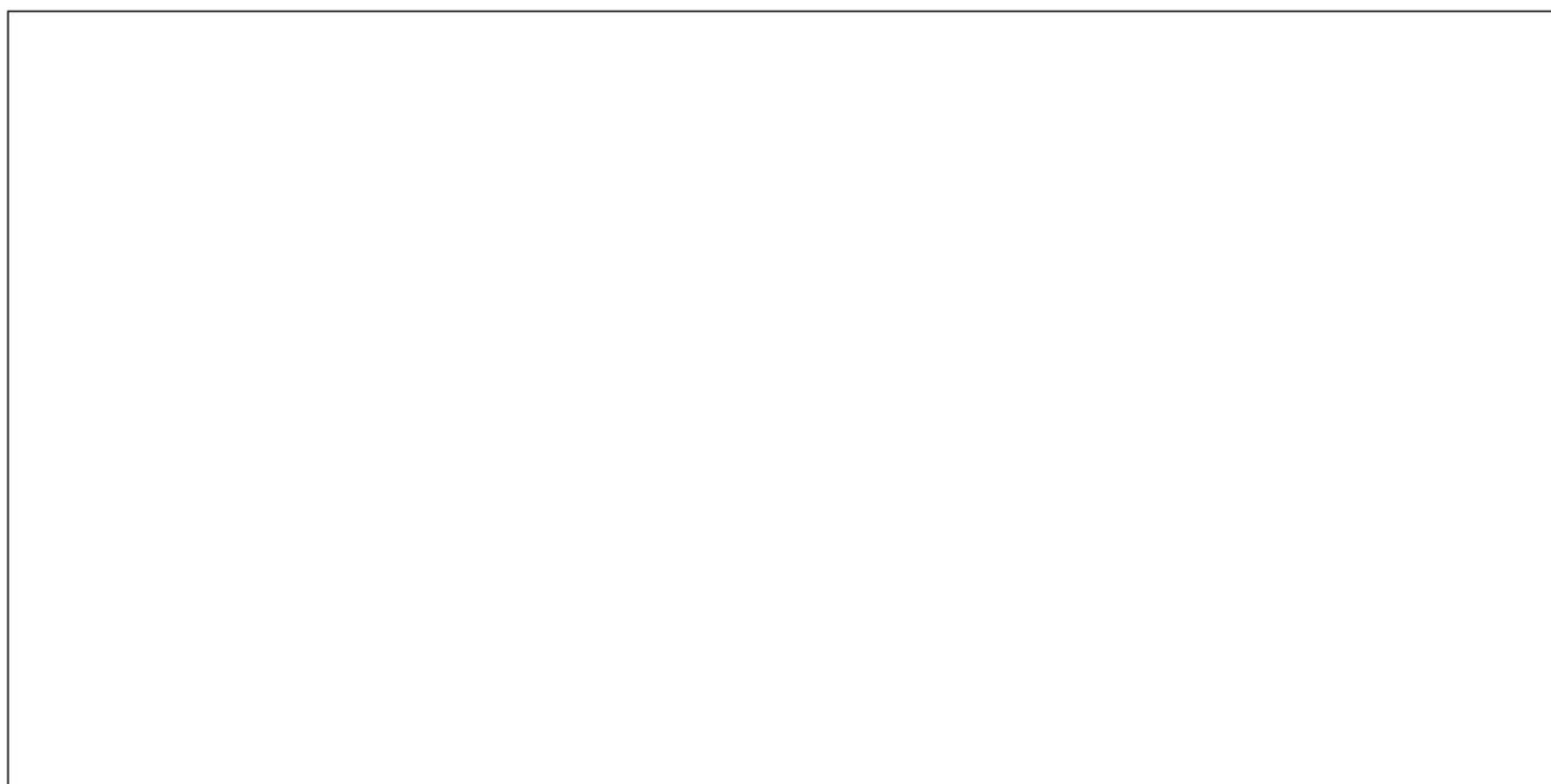
- ☐ a magnifying glass
- ☐ drawing materials

WORKING METHOD

- Find a plant with catkins (birch, oak, alder, hazel, willow).
- Collect a catkin with a carpel and a catkin with a stamen.
- Make drawings of the catkins.



- Carefully take a female catkin (with a carpel) apart and examine a fruit. Use the magnifying glass for this.
- Make a drawing of a single fruit.



Summary

BASICS 1

FLOWERS

1 You can name the parts of a flower with their features and functions.

- Calyx (sepals).
 - usually green
 - to protect the flower in the bud against drying out and against the cold
- Corolla (petals).
 - often large and strikingly coloured, sometimes small and green
 - function (if they are strikingly coloured): attracting insects
- Stamen: male reproductive organ.
 - filament and anther with pollen sacs
 - function: to produce pollen grains (male sex cells) in the pollen sacs
- Carpel: female reproductive organ.
 - stigma, style and ovary with one or more ovules
 - function: to produce egg cells (female sex cells) in the ovules
 - Each ovule produces a single egg cell with a nucleus.

BASICS 2

POLLINATION

2 You can describe what pollination is.

- Pollination: transferring pollen from a stamen to the stigma or stigmas of a flower of the same plant species.

3 You can explain the difference between cross-pollination and self-pollination.

- Cross-pollination: pollen from a stamen gets onto the stigma of another plant (of the same species).
 - Cross-pollination is done mostly by insects and by the wind.
- Self-pollination: pollen from a stamen gets onto a stigma of the same plant.

4 You can write down the features of insect-pollinated flowers and wind-pollinated flowers.

- insect-pollinated flowers: flowers in which pollination is done by insects.
 - The flowers are usually large, strikingly coloured, scented and contain nectar.
- wind-pollinated flower: flowers in which pollination is done by the wind.
 - The flowers are generally small and inconspicuously coloured, unscented and do not contain nectar.
 - Anthers and stigmas often protrude from the flower.

BASICS 3

FERTILIZATION

5 You can describe the fertilization process in seed plants.

- After pollination there will be one or more pollen grains on the stigma.
 - A pollen tube starts to grow from a pollen grain down inside the style to an ovule in the ovary.
 - Fertilization: the pollen grain nucleus fuses with the egg cell nucleus.
 - The ovule then contains an embryo.

6 You can describe the changes in the ovule after fertilization.

- The plant embryo (or germ) develops.
 - When a seed germinates, the germ grows into a seedling.
- An ovule (with a plant embryo) develops into a seed.

BASICS 4

FRUITS AND SEEDS

7 You can describe the changes in the ovary after fertilization.

- An ovary grows into a fruit.
 - One or more ovules start to grow in the ovary.
 - The ovary becomes larger and the petals fall off.
- Pulp: the soft and sometimes edible part of the fruit.
 - apple, pear: pulp appears from the flower receptacle
 - banana, pineapple: pulp appears from the ovary
- A fruit can contain one or more seeds.

BASICS 5

ASEXUAL REPRODUCTION

8 You can explain why asexual reproduction means that the offspring have the same hereditary characteristics as the parent.

- Asexual reproduction: part of the parent organism grows into a new organism.
- In asexual reproduction, the offspring have exactly the same hereditary characteristics as the parent.
 - All parts of an organism have the same chromosomes in the nucleus.
 - The chromosomes are copied when the cell divides.

9 You can give examples of asexual reproduction.

- Tuber: a thickened stem with reserves of food and buds, e.g. potato.
 - When a tuber starts to grow, a new plant comes from one of the buds.
 - New tubers grow from each of these plants, and those tubers can in turn grow into new plants.
- Bulb: a bulb base with buds and thickened leaves for storing food, e.g. tulip.
 - When a bulb starts to grow, a new plant grows from one of the buds.
 - The other buds develop into new bulbs, each of which can in turn develop into a plant..
- Runner: a stem above the ground from which young plants can grow, e.g. strawberry.
- Rhizome: a stem below the ground from which young plants can grow at various places, e.g. lily of the valley.
- Propagation: asexual reproduction as used by plant growers.
 - cuttings: taking a piece of stem or leaf that a new plant can grow from
- Tissue culture: nodes (growth sites) can grow and become new plants.
 - Tissue culture can produce a large number of plants very quickly.
- Single-celled organisms such as bacteria reproduce by cell division (fission).
- A jellyfish starts life as a polyp.
 - Small jellyfish grow in the polyp, fused together.
 - The baby jellyfish separate and grow to become adult jellyfish.
 - New polyps are produced by sexual reproduction.

BASICS 6

SEXUAL REPRODUCTION

10 You can explain that each of the parents provides 50% of the DNA in sexual reproduction.

- Sexual reproduction: fertilization takes place.
- In sexual reproduction, the offspring do not have exactly the same hereditary characteristics as the parents.
 - Sexual reproduction always involves two sex cells.
 - Sex cells are created by a special form of cell division, meiosis.
 - The chromosomes are split during meiosis.
 - During fertilization, the DNA of two organisms is merged.

11 You can give examples of sexual reproduction.

- Seed plants.
- All animals use sexual reproduction, e.g. mammals, amphibians, birds, insects.
- External fertilization: fertilization takes place outside the body.
 - among animals that live in water, e.g. frogs and fishes
- Internal fertilization: fertilization takes place in the body of the female, e.g. insects, birds, mammals.

EXTRA 7

DISPERSAL OF SEEDS AND FRUITS (IN DEPTH)**12 You can see how the fruits and seeds of a plant are dispersed from pictures of the plant (or parts of it).**

- Dispersal by the plant itself.
 - Fruits pop open when they are ripe and the seeds spring out or are flicked away.
- Dispersal by the wind.
 - Fruits (containing seeds) with fluff or wings
- Dispersal by animals.
 - Fruits (berries) are eaten and the seeds are passed through undigested in the droppings.
 - Winter stocks are not completely consumed or get forgotten.
 - Fruits with small hooks so that they stick onto the fur of animals.

EXTRA 8

MALE AND FEMALE ORGANS (EXTENSION)**13 You can name male and female reproductive organs in plants and animals.**

- Unisexual flowers: only have stamens (male) or only carpels (female).
- Bisexual flowers: contain both stamens and carpels.
- Monoecious plant species.
 - plant species with bisexual flowers and plant species with male and female flowers on the same plant
 - Self-pollination is possible in monoecious plant species.
- Dioecious plant species.
 - plant species in which any one plant has only male or only female flowers
 - Self-pollination is not possible in dioecious plant species.
- Cloaca: sexual orifice of birds (both male and female).
 - Mating: birds press the cloaca openings together.
- Hemipenis: double penis in snakes and lizards.
 - This lets the male make contact with the female from either the left or the right.

RESEARCH

LEARNING HOW TO DO RESEARCH & PRACTICAL ACTIVITIES**14 You can give a written presentation of an investigation.**

 Go to the *Flash cards* and the *Diagnostic test*.

Glossary

A

actions handelingen

Iets wat een organisme doet.

adequate stimulus adequate prikkel

Type prikkel waar een zintuigcel speciaal gevoelig voor is.

adrenaline adrenaline

Hormoon dat wordt afgegeven door de bijnieren en ervoor zorgt dat het glucosegehalte van het bloed stijgt.

amplitude amplitude

Uitslag van geluidstrillingen.

antagonistic pair antagonistisch paar

Twee spieren met een tegengestelde werking.

anther helmknop

Knop aan het uiteinde van een meeldraad.

arched gewelfd

Gebogen vorm waardoor het gewicht van iets beter gedragen kan worden.

asexual reproduction ongeslachtelijke voortplanting

Voortplanting waarbij geen bevruchting plaatsvindt.

attachment site aanhechtingsplaats

Plaats waar een pees aan een bot vastzit.

auditory canal gehoorgang

Deel van het oor dat geluiden naar het trommelvlies geleidt.

auditory nerve gehoorzenuw

Deel van het oor dat impulsen naar de hersenen geleidt.

auditory ossicles gehoorbeentjes

Deel van het oor dat trillingen van het trommelvlies doorgeeft aan het venster.

auditory receptors gehoorzintuigen

Organen in het oor die reageren op geluid.

auricle oorschelp

Buitenste deel van het oor dat trillingen opvangt.

automatic movement geautomatiseerde beweging

Beweging die je kunt uitvoeren zonder erbij na te denken.

axons uitlopers (van een zenuwcel)

Delen van een zenuwcel die impulsen van en naar het cellichaam geleiden.

B

ball-and-socket joint kogelgewricht

Gewricht waarbij de gewrichtskogel van het ene bot draait in de gewrichtskom van het andere bot.

bar chart staafdiagram

Diagram met staven die de gemiddelden van groepen weergeeft.

basal layer kiemlaag

Onderste laag van de opperhuid die bestaat uit levende cellen.

basilar membrane basilair membraan

Membraan in het slakkenhuis dat bij elke toonhoogte op een specifieke plaats gaat trillen.

biceps biceps

Spier die nodig is om de onderarm te buigen.

bisexual tweeslachtig

Het hebben van zowel meeldraden als stampers.

blind spot blinde vlek

Plaats in het netvlies waar de oogzenuw het oog verlaat en waar geen zintuigcellen liggen.

blood sugar level bloedsuikerspiegel

Glucosegehalte van het bloed.

bone botweefsel

Hard weefsel in het skelet dat bestaat uit botcellen, kalkzouten en collageen.

bones botten (beenderen)

Delen van het skelet die stevigheid geven, beweging mogelijk maken, bescherming bieden aan kwetsbare organen en vorm geven aan het lichaam.

bruise (contusion) kneuzing

Beschadiging van weefsel zonder dat er iets is gescheurd of gebroken.

buds knoppen

Delen van een knol waar nieuwe planten uit kunnen groeien.

bulb base bolschijf

Heel korte stengel van een bol.

bulbs bollen

Delen van bolgewassen die bestaan uit wortels en rokken.

burn brandwond

Beschadiging van de huid die wordt veroorzaakt door warmte, een chemische stof of elektriciteit.

C

calcium phosphate kalkzouten

Stof die stevigheid geeft aan botweefsel.

calyx bloemkelk

Groen gedeelte van een bloem dat bestaat uit kelkbladeren.

carpel stamper

Vrouwelijk voortplantingsorgaan van een plant.

cartilage kraakbeenweefsel

Buigzaam weefsel in een skelet, dat bestaat uit kraakbeencellen en collageen.

cell body cellichaam

Deel van een zenuwcel waarin de celkern zit.

central nervous system centrale zenuwstelsel

Deel van het zenuwstelsel dat wordt gevormd door de hersenen en het ruggenmerg.

chain of behaviour gedragsketen

Het effect van een handeling leidt tot een volgende handeling.

choroid vaatvlies

Middelste, goed doorbloede laag van een oogwand dat zorgt voor de voeding van het oog.

cloaca cloaca

Opening in het onderlijf van vogels of reptielen waarin het geslachtsorgaan, de darm en de urineleider uitmondt.

cochlea slakkenhuis

Deel van het oor dat bestaat uit vloeistof, het basilair membraan en zintuigcellen.

cold receptors koudezintuigen

Organen in de huid die reageren op temperaturen kouder dan de huid.

collagen collageen

Lijmstof die zorgt voor de buigzaamheid van botten.

concave bone gewrichtskom

Onderdeel van een gewricht waarin de gewrichtskogel draait.

concave lenses holle lenzen

Lenzen die bijziendheid corrigeren.

conscious reaction bewuste reactie

Een zelf gekozen reactie die ontstaat doordat impulsen van de zintuigen eerst naar de hersenen gaan, voordat de impulsen naar de spieren gaan.

control group controlegroep

Groep in een experimenteel onderzoek die niet wordt blootgesteld aan een bepaalde factor.

convex bone gewrichtskogel

Onderdeel van een gewricht dat draait in de gewrichtskom.

convex lenses bolle lenzen

Lenzen die verziendheid corrigeren.

coordination coördinatie

Samenwerking van verschillende spieren in het lichaam tijdens een activiteit.

cornea hoornvlies

Voortzetting van het harde oogvlies aan de voorkant van de iris en pupil.

corneal layer hoornlaag

Bovenste laag van de opperhuid, die bestaat uit resten van dode cellen.

corolla bloemkroon

Deel van een bloem dat bestaat uit de kelkbladeren.

cross-pollination kruisbestuiving

Overbrengen van stuifmeel van een meeldraad op een stempel van een andere plant (van dezelfde soort).

D**decibel** decibel

Eenheid van geluidssterkte.

dermis lederhuid

Onderste laag van de huid waarin zintuigen, zenuwen, pijnpunten, haarspiertjes, bloedvaten en zweetklieren liggen.

dioecious tweehuizig

Het dragen van alleen mannelijke bloemen óf alleen vrouwelijke bloemen.

dislocation ontwrichting

Blessure waarbij de gewrichtskogel uit de gewrichtskom schiet.

double S-shape dubbele-S-vorm

Vorm van het menselijk wervelkolom.

duration of exposure blootstellingsduur

Tijd waarin een oor is blootgesteld aan geluid.

E**eardrum** trommelvlies

Deel van het oor dat door geluiden in trilling wordt gebracht.

earwax glands oorsmeerkliertjes

Kliertjes in de gehoorgang die oorsmeer produceren.

egg cell eicel

Vrouwelijke geslachtscel.

endocrine system hormoonstelsel

Alle hormoonklieren in het lichaam.

epidermis opperhuid

Bovenste laag van de huid die bestaat uit de hoornlaag en opperhuid.

ethogram ethogram

Beschrijving van de handelingen van een dier.

ethology ethologie

Studie van gedrag.

eustachian tube buis van Eustachius

Deel van het oor dat de trommelholte met de keelholte verbindt.

external fertilization uitwendige bevruchting

Bevruchting die buiten het organisme plaatsvindt.

external stimulus uitwendige prikkel

Prikkel die van buiten het lichaam komt.

eye muscles oogspieren

Spieren die het oog in de gewenste richting draaien.

F

feedback terugkoppeling

Bijsturen van een proces.

fertilization bevruchting

Versmelten van de kern van een mannelijke geslachtscel met de kern van een vrouwelijke geslachtscel.

filament helmdraad

Steel van een meeldraad.

fitness conditie

Hoe gemakkelijk, lang of snel iemand kan bewegen.

fixed action patterns protocol

Lijst van achtereenvolgens waargenomen handelingen uit een ethogram.

follicle haarzakje

Uitstulping van de kiemlaag in de lederhuid waar een haar uitgroeit.

fontanelles fontanellen

Ruimten tussen de botten van de schedel van een baby.

food storage leaves rokken

Verdikte bladeren van een bol.

fovea gele vlek

Plaats in het centrum van het netvlies met zintuigcellen waarmee je het scherpst kunt zien.

fracture botbreuk

Blessure aan het bot waarbij deze in twee of meerdere stukken breekt.

fruit vrucht

Deel van een plant waar zaden in zitten.

fused vergroeid

Twee of meer beenderen zijn één geheel geworden.

G

gelatinous core geleïachtige kern

Veerkrachtig deel van een tussenwervelschijf.

gland klier

Orgaan dat bepaalde stoffen produceert.

glucagon glucagon

Hormoon dat glycogeen in de spieren en lever omzet in glucose.

glycogen glycogeen

Reservestof die wordt opgeslagen in de lever en in de spieren.

growing tip groeipunt

Afgesneden knop van een plant waaruit nieuwe plantjes groeien.

H

habituation gewenning

Vermindering van het aantal impulsen als gevolg van een aanhoudende prikkel.

heat receptors warmtezintuigen

Organen in de huid die reageren op temperaturen warmer dan de huid.

hemipenis hemipenis

Eén van de twee penissen bij reptielen.

hertz hertz

Eenheid van geluidsfrequentie.

hinge joint scharniergewricht

Gewricht waarbij het ene bot als een scharnier ten opzichte van het andere bot beweegt.

hormones hormonen

Stoffen die de werking van organen regelen.

hunch bochel

Krom vergroeide rug.

I

impulse frequency impulsfrequentie

Aantal impulsen per seconde.

impulses impulsen

Elektrische signalen die ontstaan wanneer zintuigcellen een prikkel ontvangen.

injury blessure

Beschadiging van een spier, bot of gewricht.

innate behaviour aangeboren gedrag

Gedrag dat niet aangeleerd hoeft te worden.

insect-pollinated flowers insectenbloemen

Bloemen waarbij insecten voor bestuiving zorgen.

insulin insuline

Hormoon dat glucose in de spieren en de lever omzet in glycogeen.

internal fertilization inwendige bevruchting

Bevruchting die binnen een organisme plaatsvindt.

internal stimulus inwendige prikkel

Prikkel die in het lichaam ontstaat.

interneurons schakelcellen

Zenuwcellen die impulsen binnen het centrale zenuwstelsel geleiden.

interpretation interpretatie

Wat iemand denkt dat een bepaald gedrag betekent.

intervertebral discs tussenwervelschijven

Schijfjes kraakbeen tussen wervels.

iris iris

Gekleurd gedeelte van het oog.

islets of Langerhans eilandjes van Langerhans

Groepjes cellen in de alvleesklier die insuline en glucagon maken.

J

joint capsule gewrichtskapsel

Weefsel dat twee botten in een gewricht verbindt en op hun plaats houdt.

joint gewricht

Beweegbare verbinding tussen twee botten.

L

learned behaviour aangeleerd gedrag

Gedrag dat ontstaat door te leren.

lens lens

Deel van het oog dat zich achter de iris en de pupil bevindt en dat ervoor zorgt dat je scherp kunt zien.

ligaments kapselbanden

Stevig weefsel dat twee botten in een gewricht op hun plaats houdt.

line graph lijndiagram

Diagram met één of meer lijnen die de ontwikkeling over een bepaalde tijd of afstand weergeeft.

long-sighted verziend

Alleen in de verte scherp kunnen zien.

M

meiosis meiose

Speciale celdeling waarbij chromosomen van de moedercel worden verdeeld over de dochtercellen.

monoecious eenhuizig

Het dragen van zowel mannelijke als vrouwelijke bloemen.

motivation motivatie

Bereidheid om te reageren op een prikkel.

motor memory motorisch geheugen

Vorm van geheugen die zorgt voor de juiste coördinatie van een beweging.

motor neurons bewegingszenuwcellen

Zenuwcellen die impulsen van het centrale zenuwstelsel naar spieren of klieren geleiden.

muscle pain spierpijn

Pijn die ontstaat na een ongewone belasting van het lichaam.

muscle strain spierscheuring

Blessure van de spieren waarbij spiervezels zijn beschadigd.

muscular system spierstelsel

Alle skeletspieren in een lichaam.

N

near-sighted bijziend

Alleen van dichtbij scherp kunnen zien.

nectar nectar

Zoet sap dat insecten aantrekt.

nerve cells zenuwcellen

Cellen in het zenuwstelsel die zijn opgebouwd uit een cellichaam, een celkern en uitlopers.

nerve zenuw

Bundel uitlopers van zenuwcellen, omgeven door een beschermende laag.

norms normen

Gedagsregels waarvan veel mensen vinden dat je je eraan moet houden.

O

observation observatie

Feitelijk gedrag dat je waarneemt.

olfactory system reukzintuigen

Organen in de neus die reageren op geur.

optic nerve oogzenuw

Zenuw in het oog die impulsen naar de hersenen geleidt.

organ muscles orgaanspiieren

Spieren in je organen die bewegen zonder dat je je daar bewust van bent.

ovary vruchtbeginsel

Deel van de stamper waar de zaadbeginsels zich bevinden.

ovules zaadbeginsels

Delen van het vruchtbeginsel waar eicellen worden gevormd.

P

pain receptors pijnpunten

Uiteinden van bepaalde zenuwen waarmee je pijn waarneemt.

pectoral girdle schoudergordel

Deel van het skelet dat bestaat uit de schouderbladen en de sleutelbeenderen.

pelvic girdle bekken

Deel van het skelet dat bestaat uit de heupbeenderen en het heiligbeen.

petals kroonbladeren

Vaak opvallend gekleurde bladeren die samen de bloemkroon vormen.

pie chart cirkeldiagram

Diagram in de vorm van een cirkel die de grootte van groepen weergeeft.

pivot joint rolgewricht

Gewricht waarbij het ene bot in de lengteas om het andere bot draait.

plant embryo kiem

Klein plantje dat ontstaat uit een bevruchte eicel door celdeling.

pod peulvrucht

Vrucht van een bonenplant.

pollen grains stuifmeelkorrels

Mannelijke geslachtscellen van een plant.

pollen sac helmhokje

Onderdeel van een helmknop waar stuifmeelkorrels worden gevormd.

pollen tube stuifmeelbuis

Buis die groeit uit een stuifmeelkorrel richting een zaadbeginsel.

pollination bestuiving

Overbrengen van stuifmeel van een meeldraad op een stempel van dezelfde plantensoort.

posture lichaamshouding

Manier waarop je staat en zit.

pressure receptors drukzintuigen

Organen in de huid die reageren op druk.

propagation vermeerderen

Toepassen van ongeslachtelijke voortplanting door kwekers.

pulp vruchtvlees

Zacht deel van de vrucht dat is ontstaan uit het vruchtbeginsel of de bloembodem.

pupil pupil

Opening in de iris waardoor licht het oog binnenkomt.

pupillary reflex pupilreflex

Reflex waarmee de grootte van de pupil wordt aangepast aan de hoeveelheid licht.

R**reflex arc** reflexboog

Weg die impulsen bij een reflex afleggen.

reflex reflex

Vaste, snelle, onbewuste reactie die ontstaat doordat impulsen van de zintuigen direct naar de spieren gaan.

response respons

Reactie op een prikkel.

retina netvlies

Binnenste laag van de oogwand waar zintuigcellen in liggen.

rhizomes wortelstokken

Ondergrondse stengels waaraan op verschillende plaatsen jonge planten ontstaan.

ribcage borstkas

Deel van het skelet dat bestaat uit de borstwervels, de ribben en het borstbeen.

RSI RSI

Blessure die ontstaat door te vaak achtereen dezelfde beweging te maken.

runner uitloper (van een plant)

Bovengrondse stengel waaraan op verschillende plaatsen jonge planten ontstaan.

S**sclera** harde oogvlies

Witte buitenste laag van de oogwand.

sebaceous glands talgklieren

Klieren in de haarzakjes die talg produceren.

seed zaad

Deel van een plant dat de kiem en het reservevoedsel voor het kiemplantje bevat.

self-pollination zelfbestuiving

Overbrengen van stuifmeel van een meeldraad op een stempel van dezelfde plant.

sense zintuig

Orgaan dat op prikkels reageert.

sensory cells zintuigcellen

Cellen in zintuigen die zijn aangesloten op zenuwen.

sensory neurons gevoelszenuwcellen

Zenuwcellen die impulsen van de zintuigen naar het centrale zenuwstelsel geleiden.

sensory system zintuigenstelsel

Alle zintuigen in het lichaam.

sepals kelkbladeren

Vaak groen gekleurde bladeren die samen de bloemkelk vormen.

setting bot zetten

Een gebroken bot weer in de goede stand zetten.

sex cells geslachtscellen

Cellen die betrokken zijn bij geslachtelijke voortplanting.

sexual reproduction geslachtelijke voortplanting

Voortplanting waarbij bevruchting plaatsvindt.

signal signaal

Prikkel of handeling bij sociaal gedrag.

sitting position zithouding

Manier waarop je zit.

skeleton skelet

Alle botten of beenderen in een lichaam.

skull schedel

Alle botten in het hoofd.

social behaviour sociaal gedrag

Gedrag waarbij de handeling van een dier (of een mens) een prikkel is voor een handeling van een soortgenoot.

sound frequency geluidsfrequentie

Snelheid waarmee de lucht trilt.

spinal column wervelkolom

Deel van het skelet dat bestaat uit de halswervels, borstwervels, lendenwervels, heiligbeen en staartbeen.

spinal cord ruggenmerg

Deel van het centrale zenuwstelsel dat impulsen vanaf de romp en ledematen naar de hersenen geleidt via zenuwen.

sprain verzwikking

Kneuzing van een gewricht.

stamens meeldraden

Mannelijke voortplantingsorganen van een plant.

stigma stempel

Bovenste gedeelte van een stamper.

stimulus prikkel

Invloed uit de omgeving op een organisme.

style stijl

Deel van een stamper dat tussen de stempel en het vruchtbeginsel ligt.

subcutaneous connective tissue onderhuids bindweefsel

Laag onder de huid waarin vet ligt opgeslagen.

suture naad

Kronkelige verbinding waar botten aan elkaar vast zitten.

sweat glands zweetklieren

Klieren die zweet produceren.

synovial fluid gewrichtssmeer

Stroperige vloeistof waardoor botten soepel kunnen bewegen.

T**taste buds** smaakknopjes

Plek aan de zijkanten van de groefjes van een tong waarin de smaakzintuigcellen liggen.

taste receptors smaakzintuigen

Organen aan de oppervlakte van een tong die reageren op smaak.

tear glands traanklieren

Klieren die traanvocht produceren.

tendons pezen

Weefsels die spieren met botten verbinden.

test group proefgroep

Groep in een experimenteel onderzoek die wordt blootgesteld aan een bepaalde factor.

threshold value drempelwaarde

Kleinste prikkelsterkte die een impuls veroorzaakt.

tissue cultivation weefselkweek

Manier van vermeerderen waarbij groeipunten worden afgesneden en in speciale voedingsbodems worden geplaatst.

touch receptors tastzintuigen

Organen in de huid die reageren op lichte aanrakingen.

triceps triceps

Spier die nodig is om de onderarm te strekken.

tubers knollen

Verdikte stengels met reservevoedsel en knoppen.

tympanic cavity trommelholte

Met lucht gevulde holte achter het trommelveel.

U**unisexual** eenslachtig

Alleen meeldraden óf alleen stampers hebben.

V**values** waarden

Dingen die mensen belangrijk vinden in het leven.

vitreous body glasachtig lichaam

Geleiachtige massa in het oog.

volume volume

Sterkte van een geluid.

W**wind-pollinated flowers** windbloemen

Bloemen waarbij de wind voor bestuiving zorgt.

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